5 Portman St., Portman Sq. Lond. W.

TRANSFUSION:

With Special Reference to Intravenous Infusion of Saline Solution.

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ANDREW ELLIOT.

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I. HISTORICAL.

The idea of Transfusion of Blood from one person to another is one of the oldest, not only in the history of the healing art, but in the wider and more comprehensive annals of the human race. From time immemorial the blood has been popularly regarded as the vital fluid, - the source of life, and the means of its maintenance. Departures from health were one and all attributed to alterations in the quantity or quality of the blood. The advance of old age itself, with all its increasing infirmities, was in like manner ascribed to the changes in the blood resulting from the growing burden of years. What wonder is it then that the popular mind instinctively turned to the transfusion of young or healthy blood, on the one hand to stay the advance of years, or on the other to antagonise the effects of disease? In the works of the early Classic writers, poetic allusions to the operation are not wanting. Ovid thus describes the rejuvenescence of Aeson at the hands of Medea the Sorceress:[1]

Stricto Medea recludit
Ense senis jugulum: veteremque exire cruorem
Passa, replet succis.

The disappearance of the signs of old age are then detailed, and the story concludes:

Aeson miratur, et olim
Ante quater denos hunc se reminiscitur annos.

In another passage Medea offers to restore youth to the father of Pelias:[2]

Stringite, ait, gladios, veteremque haurite cruorem,
Ut repleam vacuas juvenili sanguine venas.

The earliest actual performance of Transfusion appears to have been the attempt made in 1492 to preserve the life of Innocent VIII, by the infusion into his veins of blood taken from three young boys. The endeavour was unsuccessful, and cost the donors their life, without in any way benefiting the aged pontiff.[3]

It was not, however, until after the discovery of the circulation of the blood, that any scientific attempts at Transfusion were made. In 1628 Harvey published his "De motu Cordis et Sanguinis in Animalibus", and thirty years later, at a meeting of French scientists, a Friar of Saint-Vannes, Robert des Gabets[4] by name, described "une autre mouvement du sang", which he called "communication", and by which he meant "the effective passage of the blood of a healthy human being, or other animal, into the veins of a feeble or sick person." The idea had been suggested to him seven years previously by

another Ecclesiastic, Eloy Pichot of Paris, and together they had devised an apparatus for the purpose, consisting of two silver canulae (tuyaux en argent), provided with valves to prevent regurgitation, and connected by a leather bag or "purse" about the size of a walnut, by which the amount of blood "communicated" could be measured.

The operation however does not seem to have been carried out by Des Gabets and Pichot, and the honour of first performing Transfusion in this way belongs to this country. The transactions of the Philosophical Society of London for November 19th. 1666, contain the announcement that the experiment had been "very successfully carried out" at Oxford, by Lower,[5] and a few days later, that "very expert anatomist" demonstrated his method before a meeting of the Royal Society at Gresham College. The animals chosen were dogs, and the procedure, briefly, as follows: The "carotoidal artery" of the donor having been exposed and ligatured, a quill is tied into the vessel below the point of ligation. Similarly, two quills are inserted, between proximal and distal ligatures, into the jugular vein of the recipient, -"one into the descendent part of the vein to receive the blood from the other dog; and the other ..... into the other part of the vein which comes from the head, out of which the second dog's own blood must run". The quills are

then connected by two or more others, and the transfusion started by loosening the ligatures on the vessels, the operation being continued till the donor "begin to cry and faint and fall into convulsions, and at last die". The recipient on being released shows no ill-effects.[6]

This "pleasant and perhaps not useless" experiment Lower stated he had already performed several times in the University of Oxford, and as to its probable value, expressed his belief, that by this means, "those animals which want blood or have corrupt blood may be supplied from other with a sufficient quantity of such as is good", - a brief statement which, after the lapse of two centuries, can hardly be improved upon as an apology for Transfusion.

A wide-spread interest in the subject was at once excited, and a series of demonstrations were arranged for and carried out by the Royal Society at Gresham College. Various speculative "queries" were propounded, and an answer sought from experiment, e.g. Will the recipient after the operation recognise those to whom he was formerly attached? Are peculiarities of scent, habits, etc., transferred from donor to recipient, or in any way altered in the recipient by transfusion from an animal of inferior class? Diseased animals were transfused from healthy, and vice versa. Attempts were made

to rejuvenate animals advanced in years, by transfusing into their veins the blood of younger and more vigorous individuals. Instead of two animals, a number were employed, the blood being supplied by the animal at one end of the series, and escapement provided for by bleeding that occupying the other, - and so on.

Allusions to these experiments are not confined to the scientific literature of the time. In the Diary of Mr. Pepys[7], for example, we find the following:

> Nov. 14th, 1666. "Dr. Croone told me that at the meeting at Gresham College tonight (which it seems they now have every Wednesday again) there was a pretty experiment of the blood of one dog let out (till he died) into the body of another on one side, while all his own ran out on the other side. The first died upon the place, and the other very well, and likely to do well. This did give occasion to many pretty wishes, as of the blood of a Quaker to be let into an Archbishop, and such like; but, as Dr. Croone says, may, if it takes, be of mighty use to man's health, for the amending of bad blood by borrowing from a better body".

Early in the following year, a distinct step in advance was made. Hitherto the recipient had been depleted and infused simultaneously, but in May 1867, Robert King[8] of London succeeded in resuscitating sheep, which had been previously bled till they seemed "past recovery", by transfusing blood from other animals. By this means the proceeding was advanced from an experiment of merely scientific interest to an operation of undoubted therapeutic value.

Meanwhile continental workers had not been idle. In

March 1667, Jean Denis of Paris,[9] assisted by Emmerez, a surgeon of the same city, transfused blood from dog to dog, varying the operation in different ways, and ultimately employing animals of different species.

A few months later, the same two experimenters for the first time ventured to operate on a human being. The case is one of interest, and although permanent benefit was not to be expected, temporary improvement was undoubtedly obtained by the operation. The patient, a lad of 15 or 16, had been suffering from an acute fever for the space of two months. He had been bled with great freedom on many occasions, and this together with constant diarrhoea and sickness, had reduced him to the last stage of exhaustion. At the urgent request of the relatives, Denis and Emmerez undertook the operation, and thirteen ounces of blood from the carotid of a lamb were transfused into the boy's arm. Improvement was rapid. The sickness and diarrhoea ceased, and the patient slept. Relapse, however, necessitated a second operation, which was again so far successful. The patient rallied for a time, but died shortly afterwards.[10]

A few days later, a healthy porter of 45 was hired for purposes of experiment. The operation was performed exactly as in the former case, about twenty ounces being transfused,

with most fortunate results. The man was delighted with the effects, and offered his services should the surgeons wish to renew the experiment.[11]

Before long another case presented itself. In December 1667, a lunatic who had escaped from control, was found wandering, naked and maniacal, in the streets of Paris, and was at once seized upon as a suitable subject for experiment. Ten ounces of blood were withdrawn from his arm, and replaced by five or six ounces from the crural artery of a calf. The man slept that night, and next day the improvement seemed to continue. Two days later, a second operation was performed, a much larger quantity of blood being transfused. Severe haematuria followed, but the patient ultimately recovered.[12]

Still another case is reported. The patient had suffered for some three weeks "with the complicated distempers of an hepatic flux, a lientery, and a bilious diarrhoea". By four physicians he had been bled and purged " as much as they thought fit", till at last he grew so weak, that he was unable to move, lost his speech and senses, and vomited all he took. A small quantity of calf's blood was infused into his arm, and rapid improvement resulted. His pulse, which had been "very low and creeping", became stronger, his convulsions ceased, he

spoke sensibly, took and retained nourishment, and fell into a quiet sleep. Next day the previous symptoms returned. For a short time, after a second transfusion, he rallied, but sank some hours later. The autopsy showed intussusception, with gangrene of the intestine[13].

In England transfusion was practised on a human being for the first time in November 1667, when an individual named Coga was transfused from a sheep by Lower and King at Arundel House, in the presence of "many considerable and intelligent persons." At the conclusion of the operation the patient "found himself very well", and urged that the experiment should be repeated[14].

From England and France as centres, the operation was carried to other European countries, notably Germany and Italy, from both of which cases are reported.

The hopes that were entertained as to the value of the procedure in the treatment of disease were, however, doomed to disappointment, and the operation fell into disrepute. Nor is this altogether to be wondered at. The cases selected, as will be seen from the few quoted, were by no means such as were likely to be benefited by the experiment. In nearly all, organic lesions of themselves fatal, existed. The operation was carried out in the crudest manner, and the wonder is rather

that even a modified form of success was obtained.

Continental operators were even more unfortunate than their English confrères. The lunatic transfused by Denis and Emmerez, two months after the operation, relapsed into his former mental condition, and, yielding to the entreaties of the patient's wife, Denis agreed to give him the benefit of transfusion. Before the operation was actually started, however, he became violent, and the proceedings were stopped. He died the same night, and the widow, at the instigation of certain members of the Medical Faculty in Paris, charged the operators with causing her husband's death. The case was duly tried, and although the man's death was clearly shown to have been due to poison administered by his wife, such was the general dislike to the operation, that its performance was prohibited by law, unless the consent of all the Faculty had been obtained. This was tantamount to absolute prohibition, and for the time transfusion fell into disuse.[15]

The decline of the operation was steady, and references to it in the literature of the times rapidly diminish in frequency. Still, the few that are to be found are not without interest. In the "Armamentorium Chirurgicorum" of Johannes Scultetus (pub. 1693) which is replete with plates of the crude surgery of the times, an illustration of the actual performance

of transfusion is given. The patient, seated in a chair, is being bled in the usual way from the right arm, while a vein in his left is connected by a tube with the carotid artery of a calf.

Heister, whose "De Chirurgia Infusoria et Transfusoria" appeared in 1739, gives a very unfavourable account of the operation, and refers with satisfaction to its prohibition in Paris.

In 1679 the use of human blood, hitherto untried, was strongly urged by Mercklinus. He relates a case in which the transfusion of an animal's blood into the arm of a phthisical patient at Rome, was followed by speedy death, and ascribes the fatal result to the use of dissimilar blood. His advocacy of human blood is however only half hearted, as will be seen from one of his closing sentences: - "tamen, pro indubitato et "infallibili praesidio, experimentorum certitudine destitutus, "praefracte jactatare nondum audeo".[16.]

Towards the close of the following century, attention was again directed to the matter by Harwood, afterwards Professor of Anatomy at Cambridge. In his "Thesis on the Transfusion of Blood" (1785) he takes a new standpoint. Abandoning the idea of curing disease, he gives his attention entirely to the question of recuscitation by transfusion, after severe, and in all

probability, fatal haemorrhage. His experiments on dogs, practically a repetition of those of King, showed the feasibility of the operation, and he was therefore encouraged to recommend its trial in the human subject.

The same experiments were performed in 1824 by Blundell,[17] and the results, as recorded in his "Researches Physiological and Pathological", (pub. 1825), are practically the same as those obtained by Harwood. One great point on which he insists is the danger of the injection of dissimilar blood. All his experiments in which dogs, previously depleted, were infused with human blood proved fatal, and he does not hesitate to state, that if canine blood had been used instead of human, the animals would "certainly have recovered".

The later researches of Panum and others have fully confirmed this fact, and have shown that the danger lies in the poisonous action of the haemoglobin of dissimilar blood on the organism. (Pitts)

Of all Blundell's work however, to my mind the most important part, in the light of recent developments, occurs in a foot-note, in which he says: "It is worth enquiring whether, when there is a deficiency of the blood, the action of the heart and arteries may be kept up for a while, so as to gain time, by the mere injection of water into the vessels; in

other words, whether blood diluted with water will support the actions of life, and to what degree it may be diluted."[18] Unfortunately he goes no further, and, beyond a passing reference towards the end of his paper, no further mention is made of the subject. A few experiments would have placed the matter on a certain basis, but he left it to others, in later years, to show the feasibility of the procedure.

Blundell's results in the human subject were by no means brilliant. His first five cases died, and although he was more successful later on, he seems to have been much discouraged by his early failures.

The further history of blood transfusion resolves itself into a discussion of the safest and most effectual methods of performing the operation. The importance of the procedure, and its possibilities in cases of imminent death from haemorrhage, were by this time generally recognised. Reports of cases in which death was averted by timely transfusion were not wanting, but still the methods were more or less crude. Dissimilar blood was universally condemned. Direct arm-to-arm transfusion was difficult with the apparatus in use. Coagulation took place, air entered the recipient's vein, death from over dose, with haematuria as a prominent symptom, was not uncommon. These and other difficulties had to be overcome and

guarded against, and to obviate them many devices were proposed.

To prevent coagulation of the transfused blood, Panum in 1863, following the lead of Dumas and Prevost (1821) and Dieffenbach (1828), advocated the use of defibrinated blood, showing that defibrination did not in any way lessen its restorative powers. A successful case recorded by Nussbaum of Munich[19] illustrates the method:

The patient, a lad of 19, was much collapsed after excision of the knee for injury. He was cold, pulseless, and evidently dying. Venesection on several persons yielded about one pound of blood. This was beaten for eight minutes, filtered through fine linen into a vessel surrounded by hot water, and injected at the temperature of 100° F. into the boy's median cephalic vein. "During the operation, the patient perceived a sensation of pleasant warmth, and a short time afterwards the pulse could again be felt, and the extremities regained their normal temperature". Amputation through the thigh was successfully performed some days later.

In June 1864, Dr. Aveling,[20] before the Obstetric Society of London, described his instrument for immediate arm-to-arm transfusion. Constructed practically on the same lines as the primitive apparatus of Lower, it consisted of two canulae connected by a tube, in the course of which an elastic receptacle

of known capacity was interposed. By this means the danger of coagulation in transitu is minimised, and the necessity for defibrination obviated.

With the same objects in view Roussel of Geneva[21] constructed a very similar apparatus. It was composed wholly of hardened pure caoutchouc which, "unlike the ordinary vulcanised caoutchouc of commerce, has no effect on the blood" and differed from Aveling's Model chiefly in the method in which the blood was withdrawn from the donor's arm, the emittent vein being opened by a lancet working inside a cupping glass. Roussel's belief in the possibilities of his instrument was considerable, as his statement before the Royal Medico-Chirurgical Society of London will show: "The motive ball", he says, "forces the blood into the anaemic vein by degrees as it draws it from the turgid veins, every particle of it having remained less than a second only out of the human vessel, enclosed in a full tube, and the blood conducted by an artificial vein and heart, hermetically closed, damp, warm and soft, as are the human vessels. The blood is not modified as regards its fibrin, globules, gas, temperature or density; it passes from one system to another with all its primtive vitality, and continues to live on, producing in the patient all the effects which it would produce in the vigorous being which supplied it". Further, he lays

down the rule that not more than - at the outside - three hundred grammes are to be injected at one sitting, and at a rate not exceeding sixty or eighty grammes per minute.

Roussel operated in this country several times. The following case may be taken as an example: A man, aged 40, was admitted into Charing Cross Hospital under Mr. Barwell, in December 1876, suffering from compound fracture of tibia and fibula. Suppuration ensued, and the patient quickly became "weaker, paler, and more anaemic, the appetite less, and more capricious". On the twenty-eighth day, Roussel transfused eight and a half ounces of blood from a healthy individual into the man's arm. Improvement was marked and rapid, and a good recovery followed.[22.]

An apparatus such as this, however, ingenious though it undoubtedly is, is not altogether perfect. Its successful application presupposes no small amount of skill and practice on the part of the surgeon. It cannot be used by an unaided operator, and its employment is frequently most imperative when assistance is least available. Disuse for a time is almost certain to derange some of the finer and more important mechanical details, and the machine, when suddenly called upon, is found wanting.

These and other considerations showed the necessity for a simpler instrument, and before long a number were devised and described. Grailly Hewitt[23.]

employed a simple glass syringe connected by means of india-rubber tubing, with a canula for insertion into the recipient's vein. The blood, obtained by venesection, is received from the donor's arm directly into the syringe, and driven onwards by a rod and piston. Very similar in principle, but somewhat more detailed in construction, is the apparatus devised by Behier.[24] Those of Matthiew,[25] Walter,[26] Jones,[27] Himes,[28] and Little,[29] are a little more complicated. An extremely simple method was adopted by Martin of Berlin.[30] In two cases of severe post-partum haemorrhage, he ran blood from the donor's arm directly into a porcelain cup, standing in a vessel of hot water, and injected it at the temperature of 100°F., without defibrination, into the patient's arm by means of an ordinary glass syringe. Both cases recovered.

In 1869, Braxton Hicks[31] suggested the possibility of preventing the coagulation of the transfused blood by the addition of saline solution; and on the advice of Dr. Pavey, adopted Phosphate of Soda as the safest and best salt to employ. From experiments on dogs, he found that blood "mixed with a solution of this salt, and kept out of the system for some time, could be reinjected into the animals without detriment."

The advantages of such a method of procedure are obvious. The donor, often a near relative, need no longer be brought to

the bedside of the patient, and the venesection being performed in another room, the chances of a free blood supply are considerably greater. The time formerly lost in whipping the blood is saved, a matter of no small importance in urgent cases. The total amount of fluid transfused is comsiderably increased, and should occasion arise, a scanty blood supply can be augmented by admixture with a greater proportion of the salt solution. The operation is simple and easy of performance, and requires no special skill or training. No expensive and complicated apparatus is necessary; an ordinary syringe used with care and judgment, answers perfectly. Lastly, the operator, instead of working in the dark as is the case with the more intricate appliances, sees exactly what he is doing, and has no longer the constant dread of introducing, when he least expects it, air or blood-clot into the circulation.

Hicks's early efforts were not successful. His first four cases treated by this "new plan" all died, but at the same time, two cases treated by the "old plan" showed no better results.[32.]

This method seems to have been adopted more extensively in Edinburgh than elsewhere. In the British Medical Journal of October 2nd, 1886, Mr. Cotterill[33.] published a striking case. A man aged 23, was admitted into Mr. Annandale's ward, suffering

from severe injuries, the result of dynamite explosion. Haemorrhage, before admission, had been considerable, and shock was well marked. Amputation of one hand was necessitated, and further amputation through the thigh would have been carried out, but for the extreme weakness of the patient. Gangrene however, supervened, and the latter operation was performed on the sixth day. Next day, after severe reactionary haemorrhage, the case became most critical. The radial pulse could not be felt, the respirations were slowed down to five in the minute, and the patient appeared to be moribund. Six ounces of blood, obtained from healthy dressers, mixed with two ounces of the phosphate of soda solution (five per cent) were injected into a vein, with "immediate improvement in the grave symptoms". The same operation was carried out on three successive occasions with marked benefit, and the man ultimately made a good recovery.

"There is no doubt", says Cotterill, "that the operation is destined to hold a far more prominent position than it has hitherto done. This is due to the fact that the method of operation has been simplified and perfected ..... and deprives the operation, as usually performed, of most of its difficulties and dangers".

Numerous other cases transfused in the same way are

reported, and in the Edinburgh Infirmary the method became common. A lad who had been operated upon for empyaema was reduced to an alarming condition by haemorrhage into the thoracic cavity, which had taken place during the night. Mr. Carmichael (Dr. Duncan's House Surgeon) had himself bled to six ounces and injected this amount, mixed with the soda solution, into the patient's arm. The boy rallied immediately, and recovered without further relapse.[34] Dr. Duncan's case of pernicious anæmia, treated by successive injections of a similar mixture may also be referred to. The number of corpuscles is said to have increased with each operation.[35] Numerous other instances might be given, but the foregoing will suffice to show the interest taken in the new method by the Edinburgh Surgeons, and the success with which it was practised.

But a still further development has to be recorded. So favourably impressed were the surgeons to the Edinburgh Infirmary with the results of this method of transfusion, that it became customary to collect the blood lost in severe operations, notably amputations for disease or injury, and to reinject it, mixed with the saline solution, into a prominent vein on the face of the stump, before the insertion of the sutures. The following cases are illustrative :-

(1) On December 21st, 1885, a man was admitted under Dr. Duncan's care, severely injured by a railway wheel. Free haemorrhage had taken place on the way to the hospital, and on admission, some hours after the accident, the patient was "palid, and collapsed, and with a pulse when perceptible, quick, irregular and fluttering". Amputation through the thigh was performed, and during the operation three ounces of blood were caught in a vessel containing phosphate of soda solution, and reinjected (eight ounces in all) into the femoral vein. Towards the conclusion of the operation the patient was in an extremely feeble condition, but after the infusion he steadily improved and ultimately recovered perfectly.[36]

(2) During amputation at the hip joint for tubercular disease in a lad of 18 under Mr. Millar's care, the blood from the stump was caught as in Duncan's case, and reinjected into the deep femoral vein. After the operation the patient showed no symptoms of shock, nor was there any depression of temperature. There was however, slight haematuria. Mr. Millar's opinion of the value of the measure is decided. "The patient being in a very weak and anaemic condition, ... it is very unlikely that he would have survived the shock of the operation, had the greater part of the blood lost not been reinjected."[37]

In Professor Chiene's wards, both methods were adopted, and I have seen successful cases of each, more especially perhaps of the latter, i.e. reinfusion of the patient's own blood, which would have been otherwise lost during the performance of severe operations.

We come now to the last stage in the development of transfusion, viz., the intravenous infusion of simple saline solution. We have seen transfusion of pure blood replaced by defibrinated blood, and that again by a mixture of blood and solution of a soda salt, the proportion of the latter varying

according to the special requirements of the case. From the fact that the proportion of blood to the phosphate solution, in transfusion by Braxton Hicks's method, seems to bear no relation to the success of the procedure, and that a feeble supply can be compensated for by increasing indefinitely the salt solution, it may be argued that the latter, and not the former, is the more active and necessary agent in bringing about the desired effect. As will be afterwards shown, the argument is sound, and the recognition of the fact that we depend more on the simple dynamic action of the transfused fluid, than on any vital properties which it may be supposed to possess, has done more than anything else to bring this means of saving or prolonging life within the reach of the unaided practitioner.

The method of saline infusion has long been known in physiological laboratories, where it has been customary by this means to revive animals exhausted by blood-loss, during the progress of experimental research. The effects of infusion in such cases were so marked and so uniformly beneficial, that, after a series of experiments on dogs which were rescuscitated by this means, Woolridge enunciated his dictum "no one should die of haemorrhage."[38]

The first application of the principle in this country however, in the case of the human subject, was not as a remedy

for blood-loss, but as a restorative agent in the collapse of cholera. In the epidemic of 1832, as well as in succeeding out-breaks of the disease, numerous cases which had reached the algid stage were treated by saline infusion.[39] I shall have to refer to this matter later on, and, for the present, it will be sufficient to say that the results were sufficiently encouraging to warrant more extensive trial of the procedure. As an illustration, the following case may be quoted :

> A seaman aged 22, was admitted into the London Hospital on August 13, 1849, suffering from an attack of cholera of twenty-four hours duration. On admission, he was in complete collapse ("as profound a case of collapse as ever seen"), and his condition was pronounced hopeless by two of the medical officers of the hospital. The infusion of eighty ounces of saline fluid, containing a small quantity of alcohol, produced marked improvement, but in four hours time the pulse again failed, and the operation was repeated. Two subsequent infusions were necessary, two hundred and fifty ounces in all being injected. After a protracted convalescence the patient ultimately recovered.

Saline infusion for haemorrhage appears to have been performed for the first time, in the case of the human subject, on the Continent. On July 10th, 1881, Landerer[40] injected one litre of solution into a vein in the arm of a patient who was dying from shock and haemorrhage, after amputation of the thigh. Temporary improvement, with recovery of consciousness ensued, but death took place an hour later.

In the same year, Bischoff[41] recorded a successful case,

in which 1250 c.c. of normal salt solution were infused for severe post-partum haemorrhage. Improvement was rapid, and perfect recovery followed.

By Kümmell of Hamburg,[42] success was obtained in a case of collapse after resection of the knee, by the injection of 500 c.c. of Saline Fluid. In another case (Nephrectomy) the injection of 1000 c.c. failed to save the patient's life.

Schwarz[43] records six cases in which he performed Infusion. In some perfect recovery could not, from the nature of the case, be expected, but the results of his efforts were sufficiently good to encourage him to make further trial of the procedure.

Of eighteen cases infused by Mikulicz of Cracow,[44] twelve recovered, the failures being explained by the extreme gravity of the case.

In this country we owe the early adoption of the measure to Jennings,[45] whose advocacy of the procedure is based on experimental results in animals, and on successful cases in the human subject. The idea was suggested to him by the cases of cholera infused in 1848 by Mr. (now Sir Spencer) Wells,[46] and a series of experiments performed on dogs fully confirmed him in his estimate of its value. His first successful case occurred on August 20, 1882. The patient, after severe ante-partum haemorrhage, became markedly collapsed, the pulse being barely

perceptible, and the skin cold and clammy, together with "extreme pallor of the face, an anxious expression of countenance, sighing respiration, and slight jactitation". Infusion of sixteen ounces of saline solution was followed by rapid reanimation. Delivery took place an hour and a half later, and the patient recovered perfectly.[47]

In the Lancet of December 20, 1882, two successful cases were published by Mr. Coates of the London Hospital[48]:

(1) When first seen, the patient was"almost moribund, from the effects of severe haemorrhage occurring fifteen days after delivery. The effect of the infusion into the radial vein of saline alcoholic solution (amount not stated) is described by Coates as "marvellous". Sight and consciousness returned, the pulse gradually and steadily improved, and convalescence was soon established.

(2) The second case was similar to the preceeding. Alarming haemorrhage occurred five days after confinement, and the condition of the patient was "most critical". Twenty-two ounces of simple warm water were infused into the median cephalic vein, with the happiest results. The pulse became regular and fuller, respiration improved, and a good recovery followed.

Another successful case was recorded by Jennings[49] in 1885, in which the infusion of rather more than a pint of saline

fluid produced rapid reanimation in a patient dying from uterine haemorrhage.

From this time, the operation rapidly increased in favour and in frequency, and numerous cases are recorded. Six cases are quoted by Spencer,[50] in which the Infusion was performed for haemorrhage occurring in obstetric practice, four of which were successful. Two of his unsuccessful cases, it is only fair to add, were practically moribund at the time of the operation, and death occurred before more than two or three ounces had been infused.

In St. Thomas's Hospital Reports for 1892, Bernard Pitts[51] quotes a series of twenty-two cases, in which Saline Infusion was performed for various conditions, including haemorrhage shock, diarrhoea, and diabetic coma. In all, the condition of the patient at the time of the infusion was most critical, but in all at least temporary benefit resulted, and in over fifty per cent. permanent recovery was obtained.

Lastly, at the meeting of the Obstetrical Society of London on December 6th, 1893, a striking series of cases was referred to by Horrocks of Guy's Hospital.[52] In each case, the Infusion was performed for haemorrhage resulting from rupture of an extra-uterine gestation, the condition being verified by operation. In all, the patient had been reduced by the haemorrhage, and by the shock of the operation, to the last stage of exhaustion, and in four, perfect recovery followed the Infusion, the

amount of fluid injected varying from two to five pints.

Numerous other cases might be quoted, occurring both in hospital and in private practice, but the foregoing will suffice to show that the procedure has much to commend it, and has in this country taken a firm hold as a life saving agent.

Certain other methods of introducing blood or other fluids into the circulation have been proposed, but these require, in the present connection, little more than mention. They are three in number, viz:

1. Injection into the peritoneal cavity.
2. Injection under the skin.
3. Injection into the rectum.

1. Intra-peritoneal Transfusion of blood for chronic anaemia was proposed first by Ponfick[53] in 1879. As the results of his experiments on dogs, he found defibrinated superior to pure blood, being (i) less irritating and (ii) more readily absorbed, and, on the whole, his account of the operation was encouraging. In three cases in the human subject the operation was carried out with good results. Slight feverishness and abdominal tenderness, however, followed the injection, but both soon passed off.

Bizzozero and Golgi[53] by a series of experiments confirmed the observations of Ponfick. They found as soon as twenty

minutes after injection, an increase of Red Blood Corpuscles and Haemoglobin in the circulating blood, the increase reaching its maximum during the first or second day, and thereafter steadily declining, and lasting generally rather more than a week.

Similar results were further reported by Hyem,[54] who holds that intraperitoneal injection has the same effects as intravenous infusion, provided the latter be slowly performed.

A series of five successful cases published by Kaczorowski[55] seemed to augur well for the future of the operation, but on the otherhand, a succession of deaths from peritonitis, such as the cases of Mosler[56] (one), Landerer[57] (one), and Dozzi[58] (two), show conclusively that the operation is not without risks of the gravest kind.

That the operation is not one of any great therapeutic value is sufficiently evident. The gain of red blood corpuscles to the circulation is but small, - 5 or 6 per cent at most, - a quantity "utterly insufficient to influence in any way the general mass of the blood" (Hunter).[59] Further, the benefit is temporary as shown by the investigations above quoted, and by the work of Hunter in later years. These results can be equally well, if not better, attained by the older plan of opening a vein; and I very much doubt whether, in these

days, an operator could be found, who would prefer this unsurgical procedure, with all its attendant risks, to the more scientific and exact method of intravenous infusion.

As a remedy for acute anaemia, intraperitoneal Transfusion of blood can never have much value. Absorption goes on so slowly that, long before any benefit has resulted, the short time at our disposal will have passed. Further, as has been pointed out by Carmichael[60], if intraperitoneal transfusion is ever to save life in acute anaemia, why should death take place, - as it not infrequently does, - from an intraperitoneal blood effusion?

There is, however, a modified form of peritoneal infusion which, in emergency, is of undoubted value. In cases of abdominal section, more especially where there has been severe haemorrhage before or during the operation, it not infrequently happens that intense collapse more or less suddenly occurs, - as a rule towards the end of the operation. The flooding of the peritoneum with warm saline solution, or even with ordinary warm water, has often been followed by rapid reanimation, due, no doubt, so far to the merely stimulating effect of the warm solution, but also, I think, in no small degree to absorption of a certain amount of the liquid. In a case of laparotomy for ruptured extrauterine gestation, at which I assisted in the

Autumn of 1889, the patient became extremely collapsed, and was evidently in a most grave condition. The abdomen was at once filled with hot water at a temperature of a little over 100° F., the edges of the abdominal incision being held up in order to increase, as far as possible, the capacity of the peritoneum. Rapid improvement occurred; the pulse could be again felt at the wrist, and the deathly pallor of the face gave way to a more natural colour. The operation was concluded with all possible speed, and the patient ultimately made a good recovery.

Three similar cases are mentioned by Mayo Robson.[61] In all, the abdomen was filled with the saline solution. "The patients directly afterwards had a better pulse, and recovered."

(2) The subcutaneous injection of blood in chronic anaemia has a strong supporter in Ziemssen.[62] In an article published in 1887, he takes a very decided stand against intravenous transfusion. On account of its hidden dangers and numerous unfavourable results, the operation had become for him "an uncomfortable one", and now that he had found a "complete substitute" in the method of subcutaneous injection, he would under no circumstances "subject a patient to the great dangers of the older operation."

That this will never replace the intravenous method in

acute anaemia, however, he fully admits.

Ziemssen's method is as follows: The skin of both patient and donor, as well as all vessels and instruments used in the operation, are rendered scrupulously aseptic. The patient is anaesthetised. The blood, taken from a vein in the donor's arm, is immediately whipped, and strained into a vessel surrounded by water at a temperature of 37° - 40° C. and is then injected deeply into the patient's subcutaneous cellular tissue, preferably over the outer or inner side of the thigh, and the part subjected to "vigorous massage" by a relay of assistants. Each injection consists of 25 grammes, and this amount may be repeated eight or ten times, or even more frequently at a single sitting. The pain occasioned by the stretching and tearing of the subcutaneous tissues is treated by the application of ice over the part. With these precautions, inflammation and suppuration are prevented. Haemoglobinuria has never resulted, and digestive or respiratory troubles are of rare occurrence.

Bareggi of Milan[63] has also worked at this method, and as the result of experiment, shows that, within a short time after the operation, red blood corpuscles are to be found in the large Lymphatic trunks of the region, whence they pass by way of the Thoracic Duct into the general circulation. Increase of

haemoglobin always follows the injections, the increase reaching its maximum within twenty-four hours, and thereafter gradually diminishing. In some cases one injection is sufficient to effect a cure, in others more are necessary.

Pernicious anaemia is, according to Ziemssen, "of all others the disease for repeated subcutaneons transfusions." One of his patients, a man of 45, was reduced to such a condition of anaemia by this disease, that he was confined to bed, any attempt at assuming the upright position being followed by threatened syncope. The transfusion on the above method of 180 c.c. of blood, was followed by severe rigors and high temperature, but after the operation the "appetite, sleep and "strength rapidly improved, and the patient passed into a con- "dition of tolerable existence". In several cases of chlorosis, reported in the same paper, distinct benefit seems to have resulted from the operation.

As a remedy for acute anaemia, subcutaneous transfusion of blood obviously cannot be recommended, but injection of saline solution under the skin has been practised with a fair amount of success in such cases. An article by Cobbe[64] in the Boston Surgical and Medical Journal for 1893 is interesting in this connection. A series of six cases are quoted in which the operation was performed for shock or haemorrhage. In each

case improvement resulted. In three cases however, this was only temporary, and death ensued after a longer or shorter interval, but in the other three the good effect was permanent, and the patients made a perfect recovery. The injection was carried out by means of a "large trocar of the aspirator pattern" connected, by six feet of tubing, with a funnel into which the liquid was poured. The skin over the inguinal region and outer side of the thigh was selected; the fluid always ran readily, and was absorbed with "astonishing rapidity".

A series of five cases is recorded in the Birmingham Medical Review for 1888 by Wilson.[65] The infusion was performed in a similar manner, the subcutaneous tissue of the pectoral region being chosen.

(3) Rectal Injection of blood was proposed by Dozzi[58] (1883) as a substitute for the intraperitoneal method of which his experience had been unfortunate, two of his patients dying in rapid succession. In four cases of pellagra treated by this means cure was obtained, after a number of injections varying from two to thirty. One and a half or two litres of fresh defibrinated ox-blood constituted one injection, the bowel having been previously washed out by a clyster.

In acute anaemia rectal injection of warm water or saline

solution has been frequently used, and with a fair amount of success. The cases quoted by Gill[66.] and Heer[67.] may be taken as examples of many others. Both were instances of severe post-partum haemorrhage, and in both, the patient made a good recovery. In the great majority of instances, this method has been carried out after haemorrhage occurring in obstetric practice, and there seems to be no doubt, that if for any reason, intravenous infusion is not possible, rectal injection may act to a certain extent as a substitute. But in severe cases, where rapidity of absorption is of paramount importance, the former method has obvious advantages which cannot be claimed for the latter even by its warmest supporters.

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II. Blood Transfusion v. Saline Infusion.

Such then is, as briefly as the circumstances permit, an account of the life-history of this operation, and of the various stages through which it has passed. It now remains to enquire which of the various methods is the most satisfactory, and of the most general applicability.

The following may be taken as the most important steps in the development of the procedure:

1. Transfusion of dissimilar blood.
2. Transfusion of human blood.
    a. Direct Transfusion.
    b. Indirect Transfusion.
    c. Transfusion of defibrinated blood.
3. Transfusion of human blood mixed with saline solution.
4. Saline Infusion.

The use of dissimilar blood is attended with such manifest dangers, that it has been universally condemned, and its discussion need not further detain us.

Transfusion of undiluted human blood has more to commend it, but each of the three methods proposed obviously labours under the same defect. The supply is of necessity small, and if the object be to counteract the effects of severe blood-loss, by restoring the original bulk of the vascular contents,

the attempt must, in the majority of instances, fall considerably short of complete success. The procedure is more adapted for the treatment of chronic cases by repeated injections of small quantities of blood. As we shall see, however, there are few occasions on which this treatment can be recommended.

While each method has certain merits of its own, perhaps the most generally useful is that of direct arm-to-arm transfusion. But even this, as already pointed out, has many objectionable features, which outweigh in great measure its undoubted advantages. The necessity for a special instrument, and for previous training and practical skill in its use, is sufficient to preclude the possibility of the operation ever becoming adapted to the needs of the general practitioner.

We have therefore to choose between transfusion of blood plus the aqueous solution of a certain salt, and the infusion of a saline fluid without the admixture of blood. The decision as to which of these is to be used obviously turns on the answer to the question, "is blood necessary". If it can be shown that the injection of blood is not a sine qua non, and that equally good results can be obtained by the intravenous infusion of a neutral fluid, such as a solution of common salt, it will be readily conceded, that the latter method has manifest advantages which cannot be claimed for the former, and possesses

a range of applicability beyond that attainable by any method of blood transfusion.

It is my purpose in this paper to direct attention more especially to certain acute conditions, in which saline infusion appears to be of value as a curative agent, and in so doing I shall have occasion to enter somewhat fully into the subject of haemorrhage. I shall therefore leave the question as to the necessity or otherwise for the injection of blood in cases of acute anaemia, until that subject is more particularly under consideration. There are, however, certain more chronic conditions, in which the transfusion of blood has been strongly advocated as a means of cure. These may be conveniently considered in the present connection.

The value of transfused blood has been the subject of exhaustive researches on the part of Panum, Landois, Hayem, von Ott, Kronecker, Sander, Hunter and many others. To the work of the last named[1] I desire to express my special indebtedness.

The following points are specially to be noted:

1. That transfused blood has no nutritive value has been shown by the results of numerous experiments. Forster and Tchiriew[2] have both shown that the administration of blood by the mouth to animals in a state of starvation, is followed by

a rise in the amount of nitrogen excreted, proportional to the amount of proteid ingested. On the other hand, intravascular injection of blood, under similar conditions, produces little or no increase in the nitrogen excreted. As a nutritive material, therefore, blood given by the mouth has a much higher value than the same quantity transfused directly into the vascular system.

By a different experimental method Gianuzzi[3] arrived at a similar conclusion. He found that if two animals were equally reduced by starvation, the one in which transfusion of blood had been repeatedly practised died at an earlier period than the other.

Similarly, Casse[4] showed that repeated transfusion of defibrinated blood, in the case of a healthy animal, was followed by loss of weight more rapid and more persistent than that caused by entire withdrawal of food.

Transfusion of blood cannot therefore be recommended as a nutritive agent in the anaemia of wasting disease.

2. The respiratory value of transfused blood has been strongly advocated as a reason for the performance of the operation. Theoretically, it may be of service in cases in which the existing red blood corpuscles are incapacitated from carrying on that function, as, for example, in poisoning by carbon monoxide.

By transfusion of blood, we can introduce into the vascular system red corpuscles, which are, at least for a time, capable of acting as oxygen-carriers. Cases such as these have been, in a few instances, treated by venesection and subsequent transfusion, with apparent benefit. The time allowed to elapse, however, between the development of the symptoms and the performance of the transfusion, renders the results of the experiment, in not a few of the cases, somewhat unsatisfactory.

The breathlessness on exertion in all forms of anaemia, traumatic or idiopathic, is not an indication for transfusion (Hunter), the condition being due to other factors than mere diminution of the red blood corpuscles.

3. With regard to transfusion of blood in order to compensate for a marked fall in the number of corpuscles I shall have more to say later. For the present, it will be sufficient to state, that there is "scarcely any condition in which the want of red blood corpuscles is a source of urgent danger" (Hunter). I shall have to point out that, even after severe haemorrhage, sufficient corpuscles are always left to supply the needs of the organism, provided they be kept in circulation. The danger does not lie in the want of corpuscles, but in the altered relations between the blood-vascular system and its contents. Transfusion of blood in such cases possesses no advantages over

simple saline infusion.

4. As an aid to blood formation there is more to be said for blood transfusion. If the failure be due to want of iron in the system, as in chlorosis, the transfusion of blood may be of some value, as supplying iron in a form in which it is easily assimilated and stored up by the organism. Free haemoglobin introduced into the blood is at once eliminated as a foreign body, chiefly by the kidneys, and to a less extent by the liver. If introduced as a constituent of red blood corpuscles, however, it remains in the circulation for a certain time, the length of which is determined by the various conditions influencing the life of the transfused corpuscles; and may thereafter be stored up in the spleen and bone-marrow, in the form of blood-pigment. It is then not liable to excretion, as in the former case, and may, theoretically, subserve an important function in blood-formation. The necessity for this method of treatment in chlorosis, however, has yet to be shown. Iron can be supplied in other ways, which are equally efficacious, while at the same time, free from risk, and much more easy of application.

In the anaemia resulting from long-continued or repeated haemorrhages, on the other hand, blood transfusion cannot be recommended as an incentive to blood formation. It has been

shown by von Ott[5] that the hydraemia resulting from Saline Infusion, although greater than that produced by blood transfusion, persists for a shorter time, and that the regeneration of corpuscles after transfusion of blood requires double the time necessary after Saline Infusion. The same conclusion was arrived at by Hunter.[6] As the results of experiments on animals, he found that after blood-loss, the return of the red corpuscles to their original number took two or three weeks. If saline infusion were performed, the result was the same; but after blood transfusion, another week or more elapsed before the original number was reached. Transfusion of blood, therefore, cannot be recommended in preference to infusion of saline fluid. The former may actually retard blood-formation, the latter is at least always harmless, and may be beneficial.

In Pernicious Anaemia and Leucocythaemia, in which defective blood formation or excessive blood destruction are the chief causes at work in producing the disease, transfusion has been advocated and practised as a method of treatment. In the former, excessive destruction is the chief factor; in the latter, disturbance of formative activity has also to be taken into account. At first sight, the addition of corpuscles to the circulation by intravascular injection of blood might appear to be a sound therapeutic measure. Further examination

however, shows the unsatisfactory nature of the procedure. The value of the transfused blood obviously depends on the life-duration of the red blood corpuscles. This, in turn, as shown by Hunter[7], is determined by two factors:

1. The amount of blood transfused.
2. The Nature of the blood destruction in progress at the time of the transfusion.

The amount transfused is in any case relatively small, - "rarely more than five per cent of the blood already in the body". No great increase in the number of corpuscles is therefore obtainable, even in the most favourable conditions as regards the second factor.

The destructive process is of two distinct kinds:- (a) "Passive" destruction, or the slow and gradual decay of the red corpuscles brought about by the changes involved in carrying on their respiratory functions; and (b) "Active" destruction in which the corpuscles are rapidly broken up, the haemoglobin escaping into the plasma, and undergoing excretion by the liver as bile pigment. The more "active" the destructive process, the shorter is the life duration of the transfused corpuscles. In the two diseases in question the "activity" of this process is its most marked feature, - so much so that the operation of transfusion has been followed, in some cases, almost immediately, by rise of temperature, rigors, haemoglobinuria and jaundice. Transfusion in such cases is not without

risk, and is, at best, attended with such rapid destruction of the injected corpuscles, that permanent benefit is not to be looked for. Nor can the operation be recommended as an aid to blood formation. As has already been pointed out even in conditions of health, the blood formative process is not accelerated, and may be even retarded by transfusion of blood. It is difficult to see how it can be otherwise in disease.

III. Conditions in which Saline Infusion is of value:

The acceptance of the views just advanced as to the advantages and disadvantages of blood transfusion obviously narrows considerably the applicability of the operation. Injections of blood in chronic blood disease do not appear to possess the therapeutic value formerly ascribed to them. We are therefore limited to certain more acute affections in which the operation has been shown to have undoubted value. In all of these, the addition of large quantities of fluid to the blood stream is essential. Bulk for bulk, blood has manifestly certain advantages over simple saline solution. All observations, however, whether made for the purpose of experiment or for the treatment of disease, tend to show that the dangers attending the injection of large quantities of blood are of so serious a nature, as altogether to outweigh any advantage which might be gained by such a method of procedure. In saline infusion we have a therapeutic measure which is free from these dangers, and which practical experience has shown to be equally efficacious as a means of treatment.

Although Saline Infusion has been chiefly referred to as a means of combating the effects of severe blood-loss, the scope of the operation has been of late years considerably widened, and we are not now confined to cases in which acute

anaemia is the only cause of the urgent symptoms. Speaking broadly, it may be said that the procedure is indicated when an individual is in a grave condition, from a deficiency of circulating fluid in the blood-vascular system. From this definition it is apparent, that two factors may be concerned in the production of the collapse which it is the object of the infusion to counteract, viz:

1. Diminution in the amount of the vascular contents.
2. Defective circulation of the vascular contents.

Commonly both causes are at work, as after severe haemorrhage. But the latter, acting alone, is sufficient in certain cases, to warrant the operation. No loss of blood may have occurred, and yet, as we shall see, stagnation of the blood in certain parts of the vascular system, produces as serious consequences as its actual escape from the blood vessels. Lastly, an excessive drain of the liquid elements of the blood, such as occurs typically in cholera, may bring about a similar condition of collapse, in which the life of the patient is seriously imperilled, and in which, in many cases, death may be averted by intravenous infusion of neutral saline fluid.

The following classification of cases suitable for Saline Infusion is therefore possible:

1. Haemorrhage.
2. Shock.
3. Cholera and allied conditions.

1. Haemorrhage.

During comparatively recent years, the views previously held as to the cause of death after haemorrhage have undergone considerable modification, and on the correctness of the newer theory, the argument for saline infusion in acute anaemia in great measure depends. As an example of the older explanation of the effects of blood-loss, the following definite statement, published by Schäfer[8] in 1879 may be quoted:

> "In cases in which speedy death is threatening in consequence of excessive loss of blood, it is not the diminution of the quantity of the circulating fluid that produces the effects we see..... It is the deficiency in quality, the diminution of the number of the oxygen carriers, the red blood corpuscles, which is the cause of the dyspnoea which is observed, and in those cases in which the actual depletion is survived even but a few minutes, the immediate cause of death. The system is suffering from a deficiency of haemoglobin, and it is obviously useless to supply it with any fluid which does not contain this."

On this theory, the quality of the blood left in the body, rather than its amount, is the cause of the symptoms produced by blood loss. At first sight this view of the matter is not without attractions, and it is not surprising that it has so long held its ground. The necessity for tissue oxygenation has been long recognised, and the part taken in the process by the red blood corpuscles has been fully appreciated. It is not unnatural, therefore, to suppose that after a sudden and severe diminution in their number, the remaining corpuscles

are unable to perform their oxygen-carrying functions with sufficient rapidity to supply the needs of the organism, the consequence being failure, more or less extensive, of functional activity. Death from haemorrhage is, therefore, death from paucity of red blood corpuscles. Consequently, it is urged by the supporters of this theory, that blood transfusion alone is serviceable in cases of profuse haemorrhage, and that the operation is of value in direct proportion to the corpuscular richness of the injected fluid.

Within the last fifteen years, however, a new theory has been advanced, which is strongly supported by experimental evidence. In 1879, it was shown by Kronecker and Sander,[9] that if dogs were bled from the carotid artery till the blood ceased to flow, the amount of blood lost estimated, and an equivalent bulk of saline solution injected into a vein, speedy recovery followed. The loss of blood corpuscles in these cases was as great as could take place under any circumstances, and yet death was averted, without the addition of fresh blood. Mere diminution in the number of corpuscles is therefore not sufficient to account for death in cases of severe haemorrhage.

Similar experiments were performed by Schwarz,[10] who came to the conclusion that even two-thirds of the total amount of blood in animals might be replaced by saline solution with

impunity. The danger from blood-loss he believed to lie in the disturbed relationship between the vascular system and its contents, and not in the diminished number of red blood corpuscles.

Landerer of Leipzig[11], Hacker of Vienna[12], von Ott of St. Petersburg[13], Kolpsteck[14], and many others have expressed similar views. The last named closes an exhaustive paper on the subject by a series of conclusions from which the following are taken:

> Death from haemorrhage occurs at a period when there is still a sufficient quantity of blood left to sustain life. It is not a consequence of an excessive loss of red corpuscles, but of the disturbances arising from abnormal distribution of the blood in the vascular system.

Bergmann of Berlin[15] strongly supports the correctness of this view. In a paper read in 1884, he refers to the work of Kronecker and Sander as proof of the fact that the quantity, and not the quality, of the blood is at fault, and that even after profound blood-loss, the remaining corpuscles are always capable of maintaining the functions of life, provided only they be kept in circulation. Saline infusion is therefore as efficient a method of treatment as blood transfusion. The latter, he admits, has undoubtedly saved life, but it has done so "by setting the stagnated blood in motion, and not by any reviving, respiratory action of the blood corpuscles".

According to Hunter,[16] in animals, after the loss of half

to two-thirds of the total quantity of blood in the body, the number of corpuscles per cubic millimetre may be found as high as 3,000,000 or 4,000,000. The absolute loss is great, the relative loss is "slight and of little importance". In man, the loss of blood can never be so great as in animals, because of the earlier occurrence of syncope.

To a certain extent these two theories rest on common ground. Failure of tissue oxygenation through the medium of the red blood corpuscles, is recognised by both to be the ultimate cause of death. It is not however to their diminished numbers that we are to look for an explanation of this failure, but to their deficient movement.

Expressed differently, the immediate cause of danger from severe loss of blood is the fall in the blood pressure which results. To the efficient maintenance of intravascular pressure the continuance of the circulation is due. In health, blood pressure is mainly dependent upon peripheral resistance, acting under the vaso-motor centre. The slighter degrees of haemorrhage can therefore be compensated for by increased resistance, and no interference with the circulation takes place. But in the more severe cases, the blood loss exceeds the compensatory action. The relation between the blood vessels and their contents becomes more and more disturbed, until a point is reached, at which the tension falls so low, that the

onward movement of the blood can be no longer maintained. The heart still continues to act - for a time strongly - but having lost its natural stimulus, the contained blood, its propulsive efforts become more and more feeble, until at last they cease altogether.

Death in such cases is rapid unless means be taken to meet the threatened failure of the circulation. This can be most readily done by the direct injection into a vessel of a certain bulk of fluid, as nearly as may be equivalent to the amount of blood lost. By this means, the intravascular contents are increased, blood-pressure is restored, and the working power of the heart reestablished. The blood remaining in the vessels is again set in motion; and, with the red blood corpuscles in free circulation throughout the body, the vital centres are fully oxygenated, and the functions of life maintained, until fresh formation of corpuscles restores the blood to its former constitution.

The quantity of the fluid injected is thus of more importance than its composition. The circulation is labouring under the mechanical difficulty of vacuity, and any liquid, which is not in itself injurious, will be sufficient to meet the emergency. Ordinary water at a suitable temperature has already been used with success (v. pg. 24). A normal solu-

tion of sodiun chloride is, however, practically always to be obtained, and is no doubt preferable. Its harmlessness and freedom from retarding influence on blood-formation have already been alluded to. A further argument for its use may be found in an observation made by Dr. Matthew Hay,[17] who points out that, during their circulation in the blood, salines exert a mildly stimulating action on the tunica intima of the vessels. Contraction of the smaller arteries and the capillaries is excited, and rise in the blood pressure results. Consequently, by the employment of salt solution in the condition under consideration, we not only increase the vascular contents, but also very materially diminish the area of the containing space. The 'restitutio in integrum' is therefore more rapidly reached than were the former of these processes alone at work.

2. Shock.

The symptoms presented by an individual suffering from the effects of profound shock are fairly constant. The surface of the body is pale, cold, and bedewed with moisture. The pulse is feeble and flickering, in many cases rapid and irregular. The respiration is shallow, and occasionally sighing in character. Relaxation of the sphincters not infrequently occurs. The intellectual powers are obscured, and the mental process slow and uncertain. The clinical picture strongly suggests the effects produced by profuse blood-loss.

The pathological cause of these symptoms, however, cannot be stated in the same definite manner. Various explanations have been offered to account for some or all of the objective signs produced. In all of these, reference to the state of the circulation bears a prominent part. The pallor of surface observed during life, and the anaemia of the great nerve centres, together with the deep-seated venous congestion, so frequently found to exist after death, obviously point to some profound disturbance of the blood-vascular system. As to the exact nature of this disturbance, however, there is considerable difference of opinion. Post mortem appearances cannot be said to offer very definite aid. The conditions described vary in the most perplexing way. Marked engorgement of the large intra-abdominal veins is perhaps more constantly found than

any other pathological appearance; but many cases have been examined in which no such obvious distention was present.[18] We have therefore, in great measure, to fall back on a consideration of the symptoms, in order to form a just conception of the pathology of the condition. The lowered bodily temperature, the state of the pulse and respiration, and the general aspect of the patient, taken together, form a strong chain of evidence in favour of profound circulatory depression. Add to this the fact that in the majority of cases the large veins of the splanchnic area are markedly distended, and we are almost driven to a theory of vascular paresis to account for the condition. Shock has been defined by Sir William Savory[19] as "the paralysing influence of a sudden and violent injury to nerves over the heart". That the heart is considerably affected cannot be denied. But cardiac enfeeblement is not the only, nor perhaps the most important, cause at work. Reflex paresis of the whole vaso-motor system, more particularly in the large and important area of splanchnic distribution, must be included as contributing a very large share to the production of the symptoms. The latter view is strongly advocated by Lauder Brunton,[20] who considers venous dilatation to be more important than cardiac failure.

The result of these two conditions, defective propulsion

and diminished vascular tension, is rapid fall in the blood pressure, and the blood tends to a state of equilibrium. Venous return to the heart is progressively lessened, and the want of its natural stimulus, acting on an already enfeebled organ, renders the cardiac contractions less and less effective. A vicious circle is thus established. The head and extremities become anaemic, and accumulation takes place in the large abdominal veins, where the blood is as valueless, for the purposes of the circulation, as if it were outside the vascular system altogether. The patient has "bled into his own belly", and is therefore, for all practical purposes, in the same condition as one who has suffered profuse blood-loss.

The immediate danger is, as in cases of haemorrhage, failure of the circulation. By the infusion into a peripheral vein of a large quantity of saline solution (three or four pints), the heart is stimulated, the vascular tension restored, and the dormant blood driven out of the abdominal veins into the general circulation.

An objection has been urged to the performance of Saline Infusion in cases of pure shock, on the ground that the infused fluid will simply add to the already existing accumulation in the abdominal veins. That it does not do so, however, is evident from the result of experiment. In consequence

of the vaso-motor stimulation, and the increased vigor of the cardiac contractions which follow the operation, the partially paralysed vessels regain their tone, the blood pressure rapidly rises, and the stagnant blood is swept on with the gathering force of the blood current.

The hydraemia induced by the injection into the blood stream of a large quantity of saline solution does not persist for any length of time. As the intravascular tension rises, the excess of water is rapidly eliminated through the capillary walls, and in a surprisingly short time - in some cases, according to Hunter, ten or fifteen minutes - no departure from the normal proportion in the blood elements can be detected.

Nor is the sudden increase to the circulation to be regarded as a source of danger to the patient. It has been shown by Sanquirico,[21.] that, without previous depletion, an amount of saline solution equal to 8 or 10 per cent of an animal's body weight may be so added with impunity.

Infusion in cases of Shock has been strongly advocated by Mayo Robson.[22.] In a paper read before the Clinical Society of London, in December of last year, he quoted two of a series of cases in which he believed the performance of saline infusion had been the means of saving life. Both of his patients had been subjected to severe surgical measures, but in neither had

there been much blood lost. Shortly after the close of the operation, marked collapse set in, and death seemed imminent. The infusion, in one case of three and a half pints, and in the other of four pints, of saline fluid, was followed by immediate improvement, and ultimately both cases did well.

A similar case is recorded by Remfrey.[23] Three hours after the performance of a simple ovariotomy, he was hastily summoned to his patient. On arrival he found her much collapsed and apparently "at the point of death". A pint and a half of saline solution was immediately infused into a vein with good result, and perfect recovery followed.

As an example of shock without haemorrhage, the following case may be quoted:[24]

> A lad of 13 was admitted into hospital in a state of "profound shock", suffering from multiple contusions over chest and abdomen, caused by the passage of a waggon wheel over his body. Vigorous stimulant treatment, including hypodermic injection of whiskey and digitalis, was tried without benefit, and the boy's condition became steadily worse. When he appeared moribund, saline infusion was instituted. After a quart had been infused, the pulse became slower and the respiration improved, signs of returning consciousness were evinced; and by the time two quarts had been thrown into the circulation, he had become perfectly rational, and his pulse could be counted at 124 per minute. The improvement was fully maintained, and the lad recovered.

3. Cholera and Diarrhoea.

Saline Infusion as a remedy for the collapse of cholera was first proposed, on theoretical grounds, in 1832 by O' Shaunessey,[25.] his object being to reoxygenate the dark blood by intravenous injection of a solution of chlorate of potash. He does not appear, however, to have carried out his idea to its practical application, the first to act on the suggestion being Dr. Latta of Edinburgh.[26.] During the epidemic of 1832, Latta treated numerous cases by injection of a solution of chloride and carbonate of soda, hoping by this means to compensate for the excessive loss of these salts, as well as of the watery constituents of the blood, which the profuse evacuations and sickness entailed. The restorative effects in his earlier cases were so striking that he was encouraged to continue, and in some instances "hundreds of ounces" were infused in the course of a few hours. In all, the relief experienced by the patient from the urgent symptoms was most marked, and although in not a few the improvement was only temporary, the results on the whole warranted more extensive trial of the procedure. Of a total of fifteen cases, one third ultimately recovered.

The method was taken up by numerous other practitioners in different parts of the country, with a varying amount of success. The following, selected from various sources, may be taken as

examples:

Operator & Place.	Cases.	Recoveries.
Dr. Tweedie (London)[27]	4	1
" Craigie (Newburn)[28]	2	1
" Murphy (Liverpool)[29]	3	2
" Girdwood (Islington)[30]	7	4
" Anderson (Rochester)[31]	5	3
Edinr. Cholera Hospital[32]	19	6
	40	17

In the London Hospital, during the same epidemic, and again in 1848-49, the new treatment was systematically carried out by Dr. Little. In the earlier outbreak the results were not encouraging, but in that of 1848 more success was obtained. Of eight recorded cases, three recovered, a percentage closely tallying with that quoted by Latta. Little's remarks on the value of Infusion are most pertinent, and no apology is needed for quoting them in full.

> " Whether or no the loss of watery and saline constituents of the blood in any degree occasions the stagnation of the blood, the fact of stagnation and imperfect circulation in the larger vessels, with imminent total arrest of capillary action is incontestible. During the stasis of the circulating fluid, and torpor of the mass of capillaries of the frame.....the system has little opportunity of throwing off the effects of the morbid poison, or of the morbid poison itself. A remedy is required that shall restore the functional activity of the lungs, heart, and circulating system, by which alone the noxious load oppressing the vital powers, and the impurities gradually accumulating in the system, in consequence of life

being carried on without proper excretion.....may be removed. Whilst the proper antidote to pestilential cholera remains undiscovered, any measure that prolongs life or retards dissolution, affords an opportunity for the elaboration of peccant materials.....or affords time for the substitution of healthy, for morbid vital actions..... to take place, is deserving of full, repeated consideration and trial. Salino-alcoholic venous injections may rank as the most powerful stimulus to the heart, capillaries and nervous system we possess."[33]

The solution used by Little was the following -

Sodium Chloride	gr. 60
Potassium Chloride	" 6
Sodium Phosphate	" 3
Sodium Carbonate	" 20
Absolute Alcohol	2 drachms.
Distilled Water	one pint.

The method employed was the injection of about two pints at a time, the operation being repeated as often as collapse recurred, and benefit seemed to reward his efforts. In one of his successful cases, more than six pints were infused in the course of seven hours, in the other two, a third of that amount was sufficient.

In 1866-67, the return of cholera to England rendered a further trial of Infusion possible. At the London Hospital, the procedure was extensively practised by Mr. L. S. Little.[34] Only cases in a condition of extreme collapse were so treated, and the records show 6 recoveries out of a total of 20 cases.

During late years no further opportunity has been offered in this country for more extensive experiments in this direction. Recent reports from the Continent, however, tend to confirm the value of the operation. During the late outbreak of cholera in Hamburg, saline injections were used "in enormously increased quantities", and repeated in individual cases two or three times, or even more frequently. "It is beyond dispute" says Reiche,[35] "that by this means, and by this means alone, a large number of patients were saved."

Equally encouraging accounts from Russian observers[36] might be quoted, but enough has been said to show that the operation has attained a position in the treatment of the advanced stage of this disease to which nothing else can aspire.

The 'rationale' of the procedure is a matter of greater difficulty. That its performance, in many cases, restores the rapidly failing vital functions is undoubted; how it does so is not so apparent. Any antidotal action on the materies morbi of cholera or choleraic diarrhoea obviously cannot be claimed for a ·75 per cent. solution of sodium chloride. Some other explanation must therefore by found.

A purely mechanical action[37] has been suggested, and at first sight would seem to be the most natural theory. The enormous losses of water reduce the bulk of the blood, till at length, the disproportion between the capacity of the vessels and their contents reaches a point incompatible with maintenance

of the circulation. The thickened blood tends to accumulate in the large veins, and the heart is still further weakened. By infusion of salt solution, we replace the water which has been withdrawn from the blood and tissues, and so restore the dynamic condition of the circulation. Death from "inspissation of the blood" (Woolridge)[38] is thereby obviated.

By Abbott of New York[39] it is further urged that the increase must have the effect of diluting and aiding in the excretion of the ptomaines produced by the comma bacillus, which would otherwise be retained in the system.

Sir George Johnston[40] strongly combats the theory that the tarry condition of the blood is due to excessive drain of its watery constituents, believing that it is accounted for by the respiration and circulation being simultaneously impeded. The cause of the collapse he holds to be obstruction to the circulation through the lungs, the "poisoned blood" exciting contraction of the pulmonary arterioles. On the injection of a hot saline solution into the veins, the liquid, mingling with the blood is the pulmonary artery, "dilutes it and so renders it less irritating to the vessels, while by its warmth it relaxes the arterial spasm, and thus allows the blood to follow on."

The opinions of Little have already been referred to (pg. 56).

Spasm of the peripheral arteries, plus cardiac enfeeblement, due to "an influence from the solar plexus," was believed by the late Hilton Fagge[41] to be the essential cause of the collapse.

Whatever view we may be inclined to adopt, however, as to the modus operandi of the procedure, the important practical fact remains, that in Saline Infusion we have a method of treatment for the collapse of cholera and other allied conditions, which is admittedly superior to any of the older means of stimulation. The fact that in no case was Infusion resorted to, till the condition of the patient had become critical from rapidly increasing collapse, is sufficient to show that the rallying-powers of the operation were put to no ordinary test. In nearly every case, at least temporary benefit followed the injection, and in over 30 per cent., permanent cure resulted. Under older methods, recoveries from this advanced stage, were comparatively few. A remedy, therefore, which can show one life saved for every three cases treated, is surely, in the words of Dr. Little, "worthy of full, repeated, consideration and trial."

Although this country has been free for many years from the ravages of cholera, cases of severe "choleraic" diarrhoea are far from rare, in which the fatal event is preceded by a

stage of collapse, closely analogous to the algid stage of the true Asiatic form. Amongst the healthy adult population death from this cause cannot be said to be common, but at the two extremes of life the mortality is very heavy. Especially is this so in infancy. In 1871-80, 63 per cent. of the deaths attributed to diarrhoea were at ages under one year, and 80 per cent. under two years; the mortality reaching to over 25 per 1000 births, a figure far exceeding that for any of the other zymotic diseases.[42.] In this "infantile diarrhoea" severe collapse frequently sets in with surprising rapidity, and if once thoroughly established, is, in my experience, seldom recovered from. If life is to be saved energetic measures must be adopted, and that without delay. In the few cases in which I have had the opportunity of seeing Saline Infusion carried out, the results have been eminently satisfactory; and I venture to think that were the procedure, either by the intravenous or subcutaneous method, systematically and persistently practised, the mortality returns among the infant population, so far as this disease is concerned, might be considerably diminished.

In the case of young children, especially if the collapse be very pronounced, considerable difficulty may be experienced in finding a suitable vein. In these circumstances, the subcutaneous method may be adopted with equally beneficial effect, the indication for its performance being, according to

Abbott, profuse and persistent diarrhoea, and the appearance of the "first signs of collapse."[39]

The following, from the records of the Great Ormond Street Childrens' Hospital, London, are instructive cases:

1. Male. 9 months. Diarrhoea. Admitted into Hospital "pale cold, shrivelled-looking, and with sunken orbits." Twelve ounces of distilled water at 101° F., containing 36 grains of common salt, and 1·1 of alcohol, were infused. Reaction was immediate. The pulse became bounding, and the face flushed. No further infusion was necessary, and the child made a good recovery.[43]

2. Male, 10 months. Diarrhoea. Reduced to a similar condition. Infused three times, fifteen, sixteen, and twenty ounces being successively introduced into the circulation. Improvement followed each injection. Ultimate result not stated.[44]

3. Male, 2 years. Twice infused for diarrhoea-collapse, half a pint on each occasion. Some improvement followed, but the diarrhoea continued, and death occurred two days later.[44]

In adult cases, less seems to have been done in the way of Infusion than in the diarrhoea of children. I have personal experience of only one case, unfortunately unsuccessful, (case III. page 93) but others have been put on record by different operators. Sufficient trial has not yet been made in cases of ordinary diarrhoea of severe type, but judging from its effects in the few cases in which the procedure has been carried out, and from its brilliant results in Asiatic cholera, one would be inclined to fortell a promising future for the operation.

To complete this part of the subject mention must be made of certain other conditions in which Saline Infusion has been practiced.

For Diabetic Coma,[45] Infusion has been performed on several occasions, and although temporary recovery to consciousness has been obtained, I can find no recorded case in which permanent benefit followed the operation.

In Uræmia, the procedure has also been tried, but as yet any definite statement as to the possibilities of the operation in this condition is unwarranted.[46.] The following case is instructive:

> Puerperal eclampsia. Fits persisted after delivery, and there was constant restlessness and twitching. After infusion into the subcutaneous tissues of the loins, of one pint of Saline Solution, the patient slept for more than an hour. The fits however returned, but after infusion of other two pints, together with a hypodermic injection of morphia (1/6 gr.) more prolonged sleep was obtained. There was no recurrence of the convulsions, and the patient recovered perfectly.

In certain cases of Poisoning (by alkaloids) the procedure has been tried experimentally in animals.[47.] The results were in some cases encouraging but sufficient has not yet been done to place the matter on an exact basis.

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IV. METHOD OF PERFORMING SALINE INFUSION.

The Instrument which I have been accustomed to use is that known as Jennings's Syphon. Although not quite so simple as some of the later appliances, it is nevertheless absolutely free from anything approaching complexity of detail, and its use entails no special knowledge or training.

In consists essentially of an india-rubber tube of some four or five feet in length, having a sinker at the one end, a silver canula at the other, and a T—shaped glass interruption about a foot from the canula.

The sinker is hollow and cone-shaped, and serves the double purpose of a funnel through which the apparatus may be filled, and of a weight to keep the end of the tube constantly under water.

The canula is sinuous in form, tapering to a blunt point. Just behind the eye, which is some little distance from the extremity, the surface has several circular grooves to facilitate and render more secure the fixing of the canula in the vein. The T-shaped interruption, besides acting as an observation tube, was originally intended by Jennings as a means of introducing bloodas well as saline solution, should occasion arise, into the patient's vessels. I have not found it necessary to employ it in this manner, but have retained it in my trans-

fusion case, as it acts as a most efficient air-trap. Its position during the infusion is that of an inverted T (⊥), and the ascending limb ends in a short clamped india-rubber tube. The whole being filled with solution, any air-bells which may have accidentally entered the apparatus, in their passage through the glass portion, at once seek the higher level, and become lodged in the upper part of the ascending limb.

The length of the tube, as compared with that of some other models, has the advantage of allowing greater variation under which the fluid is allowed to enter the blood-vessel. On the other hand, it has the disadvantage of permitting greater cooling to take place during its passage. This, however, can be compensated for by increasing the initial temperature in the reservoir. And, after all, practical experience shows that, with the low condition of rubber, the loss of heat is but small.

Kinking of the tube as it passes over the lip of the vessel containing the solution, is prevented by the use of a vulcanite shoulder.

It is well if possible to have the reservoir transparent and graduated, in order that it may be seen at a glance at what rate the fluid is infused.

The whole apparatus, with the exception of the reservoir,

together with a scalpel, an aneurism needle, a pair of dissecting forceps, a couple of pairs of "bull-dog" forceps, suture needles, sterilised silk, and an antiseptic, can be conveniently packed into a small case, so as to be ready against emergency.

The practical application of the apparatus is equally simple. The rservoir, tube, and canula having been carefully disinfected (preferably in a 5 per cent. aqueous solution of carbolic acid, which is washed out with Boracic Acid solution or plain boiled water) the tube is filled as above described through the inverted sinker, the canular end clamped, and the whole left immersed in the saline fluid at the proper temperature. A suitable vein in the patient's arm is then dissected out, and a double silk ligature passed underneath it by means of the aneurism needle. One of these may be for the present left loose, the other being used in the first instance to secure the canula. The vessel is then opened, the canula inserted, tied in position by a single knot, and the infusion started by removing the clamp from the tube. On the withdrawal of the canula, both ligatures are drawn tight and securely knotted, and the vessel divided between them. The wound is closed by one or two sutures, a small dressing is applied, and the operation is complete. It is well, immediately before inserting the canula, to allow a few ounces of the solution to

run to waste. Besides testing the working of the apparatus, and washing out any remaining antiseptic, this provides for the escape of any of the fluid which may have cooled in the tube.

The whole procedure is carried out with strict antiseptic precautions as to skin, instruments, ligatures, etc.

The operation is thus one of the simplest, and its performance requires no prolonged training or experience. Anyone possessed of the most rudimentary knowledge of surgical principles can carry it out without let or hindrance. Further, no special or complicated instrument is necessary. The apparatus described is convenient, and, personally I prefer it to others which I have seen. But it is by no means a sine que non. A canula, a short length of indiarubber tubing, and a glass funnel, are perhaps more commonly used, and answer the purpose perfectly.

Any or all of these component parts however, may be dispensed with, and the operation carried out satisfactorily. The canula is perhaps the most important item, but even that is not necessary. A small-sized catheter, the canula of an aspirator, the nozzle of an ear-syringe, a Eustachian catheter, a needle for hypodermic injection, and many other substitutes have been successfully used. Tubing from an infant's feeding bottle and an ordinary kitchen funnel can be procured in many

houses to complete the apparatus. Failing that, the anterior half of a Higgenson syringe which has been divided through the ball, makes an excellent substitute for both tube and funnel. Or again, a funnel may be improvised by knocking the bottom off an ordinary pint bottle, and passing a piece of glass tubing, or a goose quill, through the cork for attachment to the india-rubber tube.

In these and many other ways which the exigencies of the case or the ingenuity of the operator may suggest, a perfectly satisfactory apparatus may be constructed, from articles which, at first sight might seem most unsuitable for the purpose. The importance of this, as regards the possibility of the operation, can hardly be over-estimated. For, whereas in the former days of blood-transfusion, a costly, complicated, and, at best, unreliable instrument, together with the cooperation of skilled assistants, was absolutely necessary to the successful carrying out of the procedure, now, saline infusion can be performed by the unaided practitioner, working single-handed, and making use of, if necessary, the common articles of ordinary domestic life.

A few points in the operation may be looked at in more detail:

Selection of vein. As a rule, the median basilic or

median cephalic is chosen, but obviously there is no special virtue in either of these, and practically the most prominent vessel at the time is made use of. In cases of extreme anaemia, it not infrequently happens, that there is some difficulty in obtaining a suitable vessel. In such cases a fillet round the upper part of the arm, together with hot sponging of the cubital space, or immersion of the elbow in hot water, will occasionally bring a vein into sufficient prominence. Should this fail, the incision must be made over the anatomical situation of a known vein. A large vessel may be then selected, as in the case recorded by Bidwell[1] in which the Femoral vein was opened, and the nozzle of a Higgenson syringe used as a canula.

The method of opening the vein is practically unimportant. A vertical incision is recommended by some, a transverse cut by others. Personally I prefer to pinch up the anterior wall of the vessel with dissecting forceps, and to incise the base of the elevated portion, with the knife held flat on the surface of the vein. The triangular flap thus raised much facilitates the introduction of the canula. During the introduction of the canula some operators allow the camp on the tube to remain in situ; others (e.g. Jennings) remove it, but plug the eye of the canula with the point of the finger. I have been in the

habit of allowing the fluid to escape gently, under low pressure. By this means, all danger of the introduction of air is prevented, and the running fluid has the advantage of washing away any blood which may exude from the wound in the vein, thus rendering the field of observation clearer.

For securing the canula in the vein, Spencer,[2.] of University College Hospital, recommends a third ligature. This I have found to be unnecessary. As above described, a single knot on one of the ligatures, especially if the silk be wet, is sufficient to retain the canula in position; and on its withdrawal, the tightening of the ligature, with the addition of another knot, suffices to secure the vessel.

Composition of the fluid. In my earlier cases I used the formula suggested by Jennings,[3.] which is a modification of that employed by Little in his treatment of cholera collapse, viz:-

Sodii Chloridi	gr. 50
Potassii Chloridi	" 3
Sodii Sulphatis	" 2½
Sodii Carb.	" 2½
Aquae	one pint.

To each pint, one or two drachms of absolute alcohol may be added, should it be thought advisable.

The above salts can be conveniently carried in powder, in quantities sufficient to make (say) two pints; and the solution may be readily prepared by dissolving the required amount in

boiling water, and adding distilled water till the requisite volume and temperature are reached.

Later investigations, however, have shown that this somewhat elaborate formula has no advantage over simple chloride of sodium, and the latter is now invariably used, in the proportion of one drachm to a pint of water.

Distilled water, it is almost needless to add, is not always available, but a perfectly efficient substitute is always to be had in boiled water which has been allowed to cool.

The temperature at which the fluid is infused is important. Strictly speaking, 100° F., is the most suitable, but no harm results from a few degrees higher. A lower temperature, on the other hand, is not to be recommended. I have been accustomed to begin the infusion with the fluid in the rservoir at # 104°F. or # 105° F., as I have found that, after passing through the whole length of the tube, the amount of heat lost amounts to about three degrees Fahrenheit. Care however must be taken in a prolonged infusion, that the solution is not cooled down with greater rapidity than one might expect. The temperature should be tested from time to time, and any loss of heat compensated for by the addition of a small quantity of boiling water.

The rate at which the fluid is infused will necessarily vary somewhat in each case. In Saline Infusion, as contrasted

with blood transfusion, no bad effects follow rapid passage of the solution into the circulation. As a general rule, a "head of water" of from two to five feet is sufficient, but in some cases more may be required, especially in the early stage. According to Horrocks[4] "the circulation is itself so rapid that a pint in four minutes is not too fast". The same opinion is expressed by Pitts,[5] who states that in the adult, "five or six pints enter the circulation with ease, taking about twenty minutes". Should, however, untoward symptoms such as dyspnoea, faintness, praecordial pain and the like, occur, the infusion can be at once slowed down, or even stopped altogether for a few seconds, by lowering the reservoir.

The total amount of fluid infused is a still more variable quantity. The only criterion is the effect produced on the patient. Jennings, in his early cases, found about twenty ounces sufficient, but since that time much larger quantities have been injected without ill-effects, and evidently with benefit to the patient. Three, four, five pints, and even more, have been thrown into the circulation to compensate for blood-loss, or to counteract the effects of shock. Lane[6] records a case in which three and a half pints were "as rapidly as possible" introduced into the basilic vein. The patient, a girl of 13, had been reduced to a most critical condition in

consequence of haemorrhage after operation for cleft palate. Although before the infusion, the patient seemed to have "only a few minutes to live," the resulting improvement was rapid and was fully maintained, and perfect recovery followed.

Horrocks[4] states that in cases of haemorrhage the amount infused should equal, as far as possible, the amount of blood-loss. In the worst cases, six pints may be necessary, in less severe cases two to five pints will suffice.

Spencer[4] has not "found it necessary to inject more than three or four pints; usually two are sufficient."

According to Pitts[6] the quantity "varies from one to eight or ten pints, depending on the effect produced."

In not a few cases, repetition of the operation may be called for. As a rule, an interval of some hours elapses between the first and second infusion, but recurrence of the symptoms may necessitate further interference in a much shorter time. (v. case V. pg. 95.). The operation is carried out in exactly the same manner as on the previous occasion, another vein in the same arm, or, preferably in the other arm, being selected. The amount of fluid required is generally less than in the primary infusion; but here again each case must be considered on its merits, and the infusion continued till the desired effect has been produced.

Entrance of Air into the Vein.

The entrance of air, along with the fluid into the vein has been mentioned several times as a possible source of danger, and all writers are agreed, that precautions should be taken to prevent its occurrence. As already stated, I have been in the habit of employing the T—shaped tube of Jennings as an air trap. But although I have watched most carefully, I have seldom seen any air-bells come down the tube with the solution in the course of the operation. It would seem, therefore, that with ordinary care, the risk of injecting air into the circulation is but small.

Further, the danger from the actual entrance of air would seem to have been somewhat over-estimated. As long ago as 1856, Hutchinson[7] stated that "the entrance of even a considerable quantity of air is not nearly so fatal an accident as is generally supposed". His experiments are instructive. To a small injecting tube, introduced into the jugular vein of a horse, he "blew as forcibly as he could for some minutes," without producing more than apparent uneasiness in the animal. It was not until a large-bore tube had been substituted, and a "very large quantity" of air had been introduced, that the animal at length fell, death ensuing in twenty minutes, after evident suffering.

Rey[8], Professor of Clinical Medicine in the Veterinary School of Lyons, showed in 1861, that if a metal canula be tied into the jugular vein of a horse, whereby air is allowed to "pass in and out" for some hours, death does not necessarily result. On the other hand, he has "very speedily killed" horses by blowing air into the jugular vein, and ligaturing the vessel above and below the wound. His conclusion is that a "considerable quantity" of air is necessary to produce death.

An experimental research on the same subject was undertaken by Panum[9]. Certain of his results may be quoted in this connection:-

1. The injection of 10 c.c. of air into the lower part of the jugular vein of a dog produced no symptoms of dangerous import.

2. After the injection of 20 c.c., the only symptom was rapid emaciation.

3. The injection of 30 c.c. was followed by death on the third day.

Certain experiments by Blundell[10], however, perhaps more nearly bear on the point at present under consideration. In order to ascertain whether the occurrence of the accident, during the course of transfusion, would cause death, he injected into the femoral vein of a dog of small size, five drachms of atmospheric air, in quantities of one drachm at a time. The animal "suffered little". Beyond some sighing, irregularity

of pulse, and muscular tremor during the operation, there was no marked disturbance, and no symptom whatever of immediate danger. A few days later, into the femoral vein of the same animal he blew "about three drachms" of pulmonary air, "without even producing temporary inconvenience".

Halford,[11] in a paper on the treatment of snake-bite by intravenous injection of ammonia, expressed the same opinion. "I had previously assured myself", he says, "that any amount of air included in the small syringes could have no injurious effect on a man ..... I had frequently injected with these syringes nothing but air, two or three times over, into the jugular veins of dogs without any harm following".

Laborde and Muron[12] attach much importance to the manner in which the injections are made, as determining the gravity of the symptoms. Provided the insufflations into the veins are done slowly, and repeated at intervals, they observe that large quantities of air are tolerated, without exciting serious symptoms. If, however, they are made suddenly and forcibly, and the amount of air is considerable, death results rapidly. The heart is found to have been arrested in diastole, due, they believe, to over-distention of the right side.

Side by side with these last conclusions, we may take three propositions enunciated in 1837, by Sir John Cormack[13] ~~of~~

~~Edinburgh.~~ The effects of the introduction of air into veins he found to be modified:-

1. By the amount of air admitted.
2. By the rapidity with which it is introduced, and the diameter of the tube or canula through which it passes.
3. By the situation of the orifice through which it enters the circulation.

The amount of air necessary to cause death has been variously stated. According to Senn,[14] "dogs weighing about 30 pounds usually recovered in a short time from an injection of 30 c.m. of air, while double that amount generally constituted a fatal dose." Halford[11] quotes Majendie's estimate of "three full inflations of the lungs" as the amount necessary to kill in the case of a horse. "

From these considerations it would appear, that the entrance of air into the venous circulation, during the process of Saline Infusion, is not to be looked upon as a necessarily fatal accident, or even as importing an element of serious danger into an otherwise simple and harmless operation. Should it occur, the amount of air is but small and its rate of entry necessarily slow. Further, the danger to the patient, in the case of a peripheral vein, is obviously less than it would be, were a vessel such as the jugular opened. The air, as has been pointed out by Cormack, Mejendie, and others, in the course

of its passage towards the heart, is either absorbed, or becomes so intimately mixed with the blood as to be incapable of causing any impediment to the circulation.

In many cases in which the procedure is called for, opportunity is afforded for the selection of a suitable instrument, and for the deliberate performance of the operation. To these the considerations adduced in the few preceding pages can hardly be said to apply. But not infrequently the infusion has to be carried out under disadvantageous circumstances, and with an apparatus hastily improvised from more or less unsatisfactory materials. In such cases, the entrance of air into the vein cannot be so carefully guarded against; and in such, it appears to me to be an important consideration, that the accident is not so unfortunate in its results as one is apt to suppose, and that, therefore, the fear of its occurrence need not deter the surgeon from allowing his patient the benefit of this life-saving operation.

V. Possibilities of the Operation.

The possibilities of the operation may be considered from three points of view:

1. The saving of life.
2. The prolongation of life for a longer or shorter period.
3. The preparation of a patient for operation.

1. The saving of life.

That the direct saving of life must be the primary object of Saline Infusion, as of any other recognised means of treatment, is sufficiently obvious. There are, I am inclined to think, at best few occasions, on which the practitioner can honestly assert that his treatment, medical or operative, has been the direct means of averting death, and of restoring his patient to health and vigour.

While this is so, however, there are, it will be readily admitted, cases of disease or accident in which skilled interference can do much to increase the patient's chances of recovery. Judicious exhibition of stimulants, the reduction of excessive body temperature, a timely performance of tracheotomy, the release of a strangulated hernia, or the removal of a hopelessly shattered limb, will occur to all as instances in point, and their causal relation to the effect produced will be

granted by everyone.

Other examples, equally convincing, might be quoted, and of these none is more striking than the subject at present under consideration. No one who has had the good fortune to witness the effects produced by the performance of Saline Infusion, in an individual brought to death's door by a severe loss of blood, will be sceptical enough to dissociate in his own mind the operation from the resulting condition. During the few minutes which the procedure occupies, the pallid countenance of approaching death is replaced by the flush of returning life; the pulsations of heart and artery can be felt to increase in force as they decrease in frequency; the shallow, hurried, and in many cases almost imperceptible respiration gives way to full, deep, regular breathing; and active reasoning intelligence takes the place of unconscious stupor. In almost none of the various operative measures at the Surgeon's command is the result so rapid or so complete, and in none is the relation of cause and effect so apparent or so easily estimated at its proper value.

That this operation can in many instances, notably in cases of haemorrhage, actually save the life of the patient, has been proved to demonstration on not a few occasions. It has been urged by Verneuil[15.] and others, that the procedure is unnecessary, and that it can lead to no results which are not

more readily obtained by subcutaneous injection of ether and other stimulants. That this is not so, is amply proved by certain experiments on dogs carried out by Hayem.[16] The animals were bled almost to the point of death, and it was found, that whereas the injection of ether was attended by no durable effect, transfusion produced a "true resurrection". The stimulation of ether induces increase of the cardiac contractions, both as regards frequency and energy, but gives rise to no increase in the blood pressure. In the less severe cases of haemorrhage, the milder and more widely known restorative agents are no doubt sufficient. But where stimulants, warmth, depression of the head, elevation or bandaging of the limbs, and other time-honoured methods of treatment utterly fail, we find in Saline Infusion a procedure whose results, if not absolutely certain, are at all events more uniformly successful, that any other measure which has yet been proposed. Through its agency individuals have been brought back again and again from the very brink of the grave; and as its use becomes more widely known and more generally practised, death from Haemorrhage, and from the other causes already detailed, will become, I am convinced, more and more rare events in the annals of medicine.

2. <u>The prolongation of life.</u>

In not a few of the cases already quoted in these pages,

the infusion of saline fluid was at once followed by an improvement, which seemed at first to be complete, and gave every promise of lasting, but which unfortunately proved to be only of temporary duration, the symptoms returning before long, and the patient relapsing into his former condition. In some cases, a second, or it may be a third operation produced permanent benefit, in others, only another temporary rally. In all these cases, it must be noted, the permanent saving of life was the object aimed at, and in as much as this was not attained, the operation must be described as a failure. There is, however, a class of case in which we can hardly hope to "save the life" of the patient, as the term is generally understood, but in which we can prolong it for a longer or shorter period, the duration of which depends on the cause at work tending to bring about his death. Case V., (page 95) is an instance in point. In this case the patient was manifestly dying from internal haemorrhage, the source of which, for reasons given, could not be reached, and whose permanent arrest was therefore impossible. The final collapse had occurred with unexpected suddenness. Her friends had been hastily summoned, but on their arrival she was only partially conscious, and quite unable to hold any conversation with them. Saline Infusion was therefore resorted to, and the result was as stated in the detailed account of the case. The patient improved at once, and for more than half an hour, talked freely and rationally with her husband, giving,

it may be, final instructions with respect to matters of mutual interest, which, but for the reviving influence of the operation, would have been left unsaid.

By Sir B. W. Richardson[17] a case in some respects similar is recorded. His patient who had been unconscious from cholera collapse, after the infusion of ~~the~~ two pints of saline fluid, recovered sufficiently to dictate his will, and sign it in proper form. Relapse, however, occurred. Infusion was repeated with the same beneficial effect as before; but, as before, the improvement was only temporary. Finally, after being resuscitated six times, the man ultimately died.

In Diabetic Coma, similar treatment has been tried in a few instances, and although I can find no recorded case in which permanent recovery ensued, in not a few, temporary return to intelligent participation in the affairs of life seems to have resulted from the operation.

That this result, temporary though it undoubtedly is, is of value, and that the means adopted are justified by the end attained, I think few will be inclined to deny. There are few, I imagine, who find time in the constant struggle for existence, to keep their affairs in such a condition that they can be safely left at a moment's notice, or who would not esteem highly the opportunity thus afforded, if not for more fully disposing of matters of financial or other importance, at least

for bidding farewell to those who may be bound to them by the ties of kindred or affection.

There is, however, another aspect of the case, which perhaps concerns the jurist more than the medical man, and which does not appear to me to have been fully recognised. It not infrequently happens that the depositions of the dying are rendered more or less valueless, by the mental impairment which the rapid approach of death entails. Is it not reasonable to suppose, that by the performance of Saline Infusion, the failing energies of mind and body may be, for a time, so restored, that reliable evidence may be obtained, to secure the conviction of the guilty, or to remove suspicion from those who are innocent?

3. The preparation of a patient for operation.

Saline Infusion before operation has not as yet been very extensively practised, but the few cases recorded seem to promise well for the future of the ~~procedure~~. It is chiefly called for in collapse from shock, or haemorrhage, or a combination of both.

The question of operation during shock is one about which there has been much discussion, and about which there is still considerable difference of opinion. With regard to certain cases there can be no difficulty or delay, as, for example, laparotomy for internal haemorrhage. But the per-

formance of primary amputation, or excision of joints, for injury, stands on a different footing. In such cases, the consensus of opinion seems to be against immediate operation. "As a general rule," says Erichsen[18], "it (operation) should be deferred until reaction comes on, as the additional injury inflicted by the operation would increase the depression under which the patient is suffering." To operate when there is no evidence of reaction is, according to Agnew[19], "to add injury to injury"; and until reaction has taken place, he advises the knife to be withheld. The same course is strongly advocated by Moullin[20], whose practice is to arrest haemorrhage if necessary, to prevent decomposition by antiseptic measures, and to wait "not until reaction is beginning, but until it has thoroughly set in," - which may not be for more than forty-eight hours.

At the same time, it is freely admitted by all, that the sooner a hopelessly mangled limb is removed, the better for the patient. Its presence tends to intensify and perpetuate the shock, and the continuance of the depression still further unfits the patient for the inevitable operation. Any means of treatment which is calculated to lessen shock, and to lead to more rapid reaction, is therefore of distinct value. Such a remedial agent we find in Saline Infusion. The arguments already referred to, in favour of its performance in cases of

haemorrhage and shock, hold with equal force here. The rationale of the operation is the same, the only difference being the time of its performance, and the immediate object in view.

It is not, of course, suggested, that Infusion should be performed before operation, in all cases in which great depression is a prominent symptom. Each case requires careful and thoughtful study and must be judged on its merits. Two main considerations will come up for discussion before deciding for or against the Infusion: viz:- On the one hand, the nature of the operation called for, together with the urgency that there may be for its immediate performance; and on the other, the extent and duration of the collapse present in the individual case. In many cases, the surgeon can safely afford to wait, until the occurrence of reaction places the patient in a condition capable of withstanding the effects of the operation he is about to perform. But in others, to which reference has already been made, to delay the operation is to reduce to a minimum any possibility of success, and yet the condition of the patient may be so grave as to preclude surgical measures altogether. The position is manifestly one of considerable embarrassment. To operate is, in all probability, to cause the death of the patient; to withhold operation, is to stand by and passively allow the same result to occur. It not infrequently happens, for example, that the surgeon is called upon

to perform herniotomy, or it may be laparotomy, upon a patient so collapsed from the effects of a long-standing strangulation, that any operative precedure is practically certain to lead to fatal consequences. The performance of Saline Infusion in such a case may, in the majority of cases will, so improve the general condition of the patient, that operation for the relief of the strangulated gut may be undertaken. A case recorded by Pilcher of Brooklyn[21] is interesting in this connection:

A woman, aged 29, was admitted into Hospital in a state of profound shock; suffering from internal strangulation of some days duration. In spite of treatment by free stimulation, the depression became more profound, until finally she became "pulseless, unconscious, and apparently dying". After infusion of eight ounces of Saline fluid into the median basilic vein, she revived, and the radial pulse appeared again "with some fulness and strength". Laparatomy was then performed. After a somewhat prolonged operation, the patient sank again into collapse, and death eventually supervened.

With regard to this (and other) cases, Pilcher remarks that an error was made in not injecting a larger quantity of the solution, and that, had the infusion been more liberal, the event might have been different.

Intra-abdominal haemorrhage affords a further example in this connection. Laparotomy offers the only chance of rational

treatment, and yet, in severe cases, operation is impossible on account of the patient's condition. It may be urged, that in this class of case Infusion is inadmissible, because of its tendency to increase the haemorrhage. That this is an objection to the procedure must be granted. It is, however, by no means a fatal one. The haemorrhage itself, if allowed to continue, must sooner or later lead to the patient's death, and the increase which may be caused by the Infusion is but slight, provided the abdomen be rapidly opened. It has, moreover, the advantage of rendering the bleeding point or points more prominent, and therefore more easily and rapidly secured. A case in point is recorded by Pitts:[22.]

> A man, aged 40, was admitted into St. Thomas's Hospital, suffering from internal injuries, the result of a fall of fifteen feet. On admission he was too collapsed to permit of operation. Next day there were signs of extensive intra-abdominal haemorrhage. The patient was very collapsed, but the infusion of four pints of Saline solution, so improved his condition, that operation was decided upon. Laparotomy revealed rupture of the spleen, and seventy-five ounces of blood were removed from the abdominal cavity. At the conclusion of the operation, other five pints were infused into the internal saphena vein at the ankle. The "man recovered well from the collapse."

Before abdominal section for rupture of one of the hollow viscera, Infusion is of the highest value. In such cases there may be little or no haemorrhage, but the shock is of the most intense kind. The following is an illustrative case:[23.]

> A young woman, aged 25, was admitted into St. Thomas's Hospital in May 1893, in a state of collapse, with symptoms pointing to ruptured gastric ulcer. She

was "too bad for any operation, being almost pulseless, extremely cold, and ..... breathing so shallowly that it was difficult to detect respiration at all." She was removed to the theatre for Infusion, in the hope that she might rally sufficiently to justify operation. Four pints of Saline solution, containing one once of brandy and one and a half ounces of absolute alcohol, were infused into her right median basilic vein with such good effect, that laparotomy was rendered possible. A perforation was found on the "outer" wall of the stomach, which was closed by sutures, and the abdominal cavity irrigated with Boracic lotion. The operation lasted an hour, and the patient "left the theatre in a very fair condition, the pulse being regular and moderately strong, and the surface of the body warm."

In primary amputation or excision, as has been already stated, the necessity for preliminary Infusion does not so frequently arise. There is less need for immediate operation, and, as a rule, time for the establishment of reaction can, should the surgeon think fit, be safely afforded. There are, however, many who are strongly in favour of early operation, urging that the presence of the injured limb is of itself sufficient to maintain the condition of collapse, and that the operation per se, especially when performed, as it always is in these days, under an anaesthetic, does not add to the existing shock. It has been my experience to see such operations performed without delay, irrespective of the condition of the patient; and although the immediate result has been, in the great majority of instances, satisfactory, I can recall more than one case, in which a fatal event might perhaps have been averted, had the patient been allowed the benefit of a preliminary Saline Infusion.

The reinfusion, towards the conclusion of the operation

of the patient's own blood, mixed with an aqueous solution of Sodium Phosphate, as practised by the Edinburg surgeons, was undoubtedly a step in the right direction; and the frequency with which this measure was employed is evidence of the value which was attached to it. I venture to think, however, that, at least in certain cases of severe injury, even more good would have been done, and the patient would have been in a better condition on leaving the theatre, had Saline Infusion been performed as the first stage in the operative procedure.

Two cases put on record by Mr. Pye Smith of Sheffield may be quoted:[24]

1. H. W. a carter, age 26, was admitted into Hospital in September 1891, suffering from gunshot wound of the leg, causing severe laceration of the soft parts, and compound comminuted fracture of tibia and fibula. There was free haemorrhage at the time of the accident, and on admission, three hours afterwards, he was "much blanched and collapsed, with small, weak and frequent pulse, and cold extremities." Amputation was evidently called for, but the patient seemed "quite unfit to undergo such an operation". Stimulants did not improve his condition, and it was therefore determined to try the effects of Saline Infusion. Under ether, a pint and a half of salt solution was injected into the internal saphena vein, at the level of the proposed amputation, with such manifest improvement in the pulse, that operation was rendered possible. Before the patient left the table, the same quantity was again injected, with still more obvious effect, the pulse becoming "most markedly fuller and less rapid." Ultimately the patient made a good recovery.

2. A lad of 18 years of age was admitted, in December of the same year, for a severe burn over the popliteal space, causing destruction of all tissues down to the bone. There had been a good deal of haemorrhage, and the patient's general condition was such, that it was

considered advisable to infuse before operating. The injection of sixteen ounces of Saline solution, so improved the pulse in rate and volume, that amputation was immediately carried out, and perfect recovery followed.

Similar cases might be related, but the foregoing will be sufficient to indicate the importance of the procedure. Its chief value will no doubt be found in cases in which immediate operation is imperative, but at the same time impracticable in consequence of the patient's extremely enfeebled condition. By the performance of free Infusion we can so revive the flagging energies, that surgical interference becomes possible, and thus afford the patient the only chance of final recovery that is open to him. In less urgent cases, the operation has also a place. By this means the surgeon can hasten the occurrence of reaction, and is thus not only enabled to operate at an earlier period than he otherwise might, but also places his patient in a better position to withstand the effects of the surgical measures which may be necessary. In any case in which there is doubt, as to whether the degree of collapse present contra-indicates operation, the performance of Infusion will generally so improve the sufferer's condition, that the matter passes beyond the region of uncertainty, and operation will be undertaken with confidence. Further, even should no manifest benefit result, at least no harm has been done; and the operator has the satisfaction of knowing, that in his efforts to improve the patient's condition, he has in no way prejudiced his chances of recovery.

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VI. CASES.

I append the following cases in which I have performed, or assisted in the performance of Saline Infusion:-

Case I.

Mary T. age 19, during convalescence from a severe and protracted attack of acute peritonitis, developed abscesses - three in number - in the abdominal wall. Under chloroform, these were opened freely, the surfaces thoroughly scraped with Volkmann's sharp spoon, and the cavities packed with iodoform gauze, wrung out of Sublimate solution. During the operation, which lasted in all about thirty-five minutes, a good deal of blood was unavoidably lost; and at its conclusion, the patient was much collapsed. The pulse was almost imperceptible at the wrist, and was running and irregular in character. Sighing respiration, and general restlessness were marked. The body-surface was cold, and sweating was rather profuse. Subcutaneous injection of Ether and Strychnine, enemata of brandy and water, together with elevation of the foot of the bed, and other appropriate methods of treatment, were tried for some time, without producing any real improvement. The alarming symptoms persisted, and the condition was evidently most grave. Intravenous Infusion was therefore carried out. On the injection of about twenty-five ounces of Saline Solution, prepared according to Jennings' formula, rapid improvement took place. The pulse became slower, fuller,

and quite regular. The sighing respiration ceased, and consciousness returned. The improvement was fully maintained, and the patient made a perfect, though slow recovery.

Case II.

Jane F., aet. 36, had suffered from menorrhagia and metrorrhagia for some months, due to Uterine fibroid. When first seen, in consequence of profuse haemorrhage, all the signs of profound anaemia were present. The patient was conscious, but extremely collapsed, and any attempt at movement was followed by threatened syncope. The face was blanched, and the mucous membranes pale. The extremities were cold. The pulse could be counted at the wrist at the rate of 130 per minute, but was feeble and slightly irregular. The respiration was hurried and shallow, and there was some disposition to throw off the bedclothes. The infusion, into the right median-basilic vein, of a pint and a half of saline solution (Jennings' Formula) was, as in the previous case, followed by speedy improvement. The colour returned to the face, the pulse became fuller and stronger, the respirations deeper and steadier, and the patient expressed herself as feeling "much better." No further infusion was necessary and the patient recovered perfectly.

Case III.

Wm. T., aet. 62., was siezed, in August 1889, with severe

choleraic diarrhoea, which at first seemed to yield to treatment. On the third day there was considerable improvement. The diarrhoea was less frequent and less profuse; there was no sickness, and the general condition was distinctly better. Twenty-four hours later, however, all the symptoms returned with increased severity. Frequent evacuations of watery stools occurred, vomiting was almost incessant, and cramps in the legs were frequent and severe. By the evening of the fourth day, the condition was most critical, from the rapid onset of collapse. The eyes and cheeks were sunken, the lips, ears, and extremities cold and blue, and the radial pulse only just perceptible. Rather more than a pint and a half of saline solution were then infused into the right arm. Reanimation quickly occurred, and the patient became quite conscious and sensible, though still exceedingly feeble. The pulse improved, and the colour became more normal. I then left, in the hope that the improvement would continue. Relapse, however, occurred in a few hours, and death took place in the early morning, - about seven hours after the performance of the Infusion.

The error in this case is, of course, obvious. Setting aside the question as to whether sufficient fluid was introduced at the primary infusion,-and indeed the effect produced seemed to justify cessation at the end of the thirty ounces, - one should have been prepared to reinfuse a second time, or

more frequently still, should the occasion arise.

Case IV.

Chas. B. aet. 12, was admitted into the West London Hospital in March 1893, with symptoms pointing to spinal caries. After an exploratory operation, which showed a bare and roughened condition of certain lumbar vertebrae, the patient for some time did well; but in July acute Morbus Coxae developed. After two partial operations, it was found necessary, in September, to amputate at the hip joint. The operation was performed by Furneaux Jordan's method, and at its close the patient was much collapsed. The pulse was almost imperceptible, and his condition appeared so grave, that Saline Infusion was carried out in the Theatre, about a pint and a half of the Salt Solution (one drachm to the pint) being infused into the median basilic vein. Marked improvement at once resulted, and the patient was removed to bed in a very fair condition. Death occurred three weeks later from faecal extravasation into the abdominal cavity, due to rupture of a tubercular ulcer.

Case V.

Agnes R., aet. 26, was admitted into the West London Hospital towards the end of May 1892, suffering from peritonitis of two weeks duration. The cause of the condition was some-

what obscure, but the history of the case suggested the rupture of an extrauterine gestation as the most probable explanation. After consultation, the abdomen was opened by Mr. Bruce Clarke. A small quantity of free blood was found in the abdominal cavity, but satisfactory examination of the pelvic organs was impossible, on account of numerous peritonic adhesions between adjacent coils of intestine. The patient rallied well from the operation, and for twenty-four hours her progress was satisfactory. At the end of that time, however, after a sudden attack of abdominal pain, she became much collapsed, and presented all the signs of internal haemorrhage. Her husband was sent for, but on his arrival, in about an hour's time, the patient was in a sub-conscious condition, and could be roused with difficulty. I therefore determined to try the effect of Saline Infusion. Two pints of salt solution were injected into a vein in the right arm, with rapid and marked benefit. At the close of the procedure, the patient was perfectly conscious, the pulse and colour had considerably improved, and she was able to converse intelligently with her relatives. In less than an hour, however, relapse occurred, and all the former symptoms returned. A second infusion was followed by considerable improvement, but the patient again relapsed, and death occurred in about an hour and a half.

The autopsy showed a large quantity of hydraemic blood in the peritoneal cavity. The right Fallopian Tube was found to be the seat of a three month's pregnancy, which had ruptured

on the posterior surface.

Case VI.

David B., aet. 25, was admitted into the West London Hospital on the 23rd of November 1892, suffering from gunshot wound of the abdomen, Laparotomy revealed three distinct penetrating wounds of the intestinal wall, which were closed by Lembert's suture. The peritoneum was thoroughly flushed with weak carbolic solution, a large drainage-tube inserted, and the wound closed. Three days later, on account of feculent discharge through the tube, Ether was again administered, in order that a second exploration might be carried out. Before complete anaesthesia was established, however, the patient became alarmingly collapsed. The radial pulse was imperceptible, the respiration became rapid and shallow, and the face and lips blanched. Four pints of Salt solution were at once infused, with distinct benefit; but further operative measures were deemed inadvisable. Death, from septic peritonitis, occurred on the fifth day.

Case VII.

Rose H., aet. 23, was admitted into the West London Hospital in December 1892, complaining of constant and profuse haemorrhage since her confinement a fortnight previously. On

admission the patient was much blanched, the pulse was rapid and small, but quite regular; the thermometer registered only 96°F. Hot antiseptic douches were ordered, and, next day, under ether, a large piece of placenta was removed from the uterus. She rallied imperfectly from the operation, the pulse remaining rapid, and the temperature much depressed. Under stimulating treatment, considerable improvement took place both in pulse and temperature, and by 9 p.m. she expressed herself as feeling "stronger". An hour later, however, the strength failed suddenly and rapidly. Saline infusion was at once carried out, but without permanent benefit, and death took place at 11 p.m.